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THE USE OF LIGHT AIRCRAFT IN SUPPORT OF FIELD ACTIVITIES IN HIGH ARCTIC LATITUDES

BY TERRIS MOORE

[*MS. received 17 December 1958.*]

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Proving flights

During the summer of 1956 W. W. Phipps flew a Piper Super-Cub aircraft solo from Pelley Lake to Eureka, and there carried out a series of local flights in Ellesmere Island on behalf of the National Film Board of Canada. The aircraft was equipped with standard tandem wheel undercarriage. Carrying one passenger, Phipps landed at Fort Conger, Alert and Cape Columbia. The round trip from Pelley Lake took 11 days covering a distance of 4500 miles in fifty flying hours.

On 25 July 1958 the writer left Ottawa with a float-equipped Piper Super-Cub to fly to Eureka. Overnight stops were made at Moose Factory, Severn, Churchill (two nights on account of low cloud), an unnamed lake 50 miles short of Baker Lake, Baker Lake itself (because of strong N.W. winds), an unnamed pond 10 miles south-west of Bellot Strait, and at Resolute.

The average prevailing N.N.W. wind over this route reduced the speed going north to about 70 to 75 m.p.h. ground speed. Had the return flight been made along the same route, the average ground speed would probably have been about 105 to 110 m.p.h. The writer, because of caution in undertaking something not done before, deliberately cruised the engine at only 2200 r.p.m. with 90 m.p.h. airspeed, for greater reliability. The manufacturer's rated cruise is 2350 to 2450 r.p.m. with 100 m.p.h. airspeed. Since the writer is now satisfied that a forced landing along this route with the Super-Cub seaplane would be only a problem and not a disaster, he would, if making the flight again, cruise at the manufacturer's faster cruise rating. It would still seem wise, however, to limit flying time to 6 to 8 hours a day in the interest of safety, since this deteriorates rapidly as the pilot becomes fatigued. All this would indicate that a ground speed of 80 to 85 m.p.h. could probably be maintained going north, and 115 to 120 m.p.h. coming south. This would imply a probable northward passage of 1 week, and 4 to 5 days coming south.

The Super-Cub equipped with wheel landing gear flown by W. W. Phipps made the passage in about half the time estimated above for the seaplane. The reasons for this are: (1) Wheel gear cruises about 10 m.p.h. faster than

float gear, all other factors being the same; (2) the wheel-equipped aircraft can land and refuel at regular airports and airstrips where refuelling is quickly and easily arranged, whereas seaplane refuelling in the north is always a cumbersome and time-consuming process; (3) Super-Cubs need 40 to 50 gallons of extra fuel in addition to the 30 gallons carried in regular wing tanks. The wheel-equipped aircraft carried this extra fuel on transit flights in a specially installed 50 gallon drum inside the cabin, occupying the passenger and baggage space, and equipped with a fuel pump to enable refuelling to be done during the flight. The seaplane carried its extra fuel in the middle compartments of the floats and therefore had to land to refuel. This was done by hand-pumping fuel out of the float compartments into a 5-gallon can, and pouring from this into the wings. On the other hand, this made it possible for the seaplane to carry a passenger (Nile Albright of the Columbia University expedition) on the return transit flight, which the wheel-equipped Super-Cub could not do.

During the 2 weeks spent in Ellesmere Island a series of flights were made in support of the field activities of the Columbia University Ellesmere Expedition, the Defence Research Board of Canada I.G.Y. party at Hazen Lake and the joint Canadian–United States weather station at Eureka. The flights in Ellesmere Island occupied forty-six flying hours and covered 4140 miles in those latitudes. The return journey south was made by way of Resolute and Alaska carrying a passenger.

Payload

The payload depends very much upon the length of the flight to be made. For example, if no passenger or baggage were carried, and only emergency equipment and extra fuel, the pilot alone could make 1000 mile flights.

The usual rule for the average length scientific flights made this summer was "a passenger of reasonably normal weight plus 50 lb. of baggage"; or the equivalent weight could be carried instead in the form of cargo, namely, about 250 lb.—depending again upon the length of the flight.

The baggage compartment will accommodate cargo the size of several medium-sized suitcases. In this particular aircraft the baggage compartment has been extended rearward to accommodate poles 5 to 6 ft. long, provided they are light in weight.

The aircraft's small size proved to be no handicap in the case of scientists taken on investigation flights in 1958, primarily because the basic transport and supply into the area had been accomplished by large multi-engine transport aircraft. Simple observational equipment, notes, specimens, etc., were readily carried in the light seaplane.

Since the Super-Cub as a cargo vehicle is basically a $\frac{1}{8}$ ton flying truck, 1000 lb. of cargo can be easily relayed in four flights of 250 lb. each to a desired location. The very low fuel consumption—only about 6·6 Imperial gallons per hour at 90 m.p.h.—means that the total fuel consumption for four flights compares not unfavourably with that of a transport aircraft carrying 1000 lb. in a single load. The Super-Cub cannot do the job so quickly, nor can

it carry single pieces weighing 1000 lb., it can, however, get into many places impossible for large transport aircraft.

Effect of weather

In the United States and southern Canada multi-engine planes have a great advantage over single engine aircraft in contending with bad weather, because there are so many alternative airports to land on in case of need, and so many widely spread radio aids to blind flying on instruments, that the safety factor of having several engines in the plane can be utilized to the full. But in high Arctic latitudes the situation is greatly altered, perhaps even reversed. At present, landing-places and radio aids for blind flying are so few and so very far apart that it is by no means a remote hazard for a multi-engine aircraft to have all its possible alternative landing-places closed in by zero-zero weather. The Super-Cub, not designed for prolonged blind flying, will take longer to get to its destination in these conditions, but has an excellent chance of doing so safely by flying "under" the weather and because it is able to land in unprepared places and wait for the weather to improve. Wheel-equipped light planes find many possible landing places because of the absence of trees and the innumerable ponds, lakes, inlets and fjords provide more landing-places for the seaplane than are available in most other areas.

During the 1958 passage north, the seaplane made landings four times, on three different days, to wait for bad weather to pass and always flew "under" the weather. One of the worst storms of the season hit the route of the flight, but, because the seaplane could land easily almost anywhere, it was possible to keep on flying beneath very low ceilings until completely unflyable areas were encountered, when the seaplane was landed and the patch of bad weather waited out. One of these landings was made on a nameless pond about 50 miles south of Baker Lake during the night of 29 July, the next one was made on a nameless small lake on Boothia Peninsula near the west side of Bellot Strait during the night of 31 July and two more waits for weather were made on nameless bodies of water near the north end of Somerset Island on 1 August.

Modifications to aircraft

For obvious reasons the cabin of every Arctic aircraft should be arranged so that the pilot can in case of need eat and sleep in his ship. This is of course easily done in the large aircraft, but it is even more important in the Super-Cub, where the pilot must sometimes land and wait for bad weather to pass. Not all lake foreshores are convenient for pitching a tent. By lengthening the baggage compartment of the Super-Cub, the writer was able to sleep quite comfortably in his ship with air mattress and sleeping-bag.

A small Primus stove designed to burn leaded gasoline enables the pilot to cook his own meals in the cabin without tent pitching. This can be a convenience in the Arctic, where messing and sleeping facilities at bases may at times be temporarily overcrowded.

Conclusions

The flights made during these two seasons have demonstrated the value of very light aircraft, such as Piper Super-Cub, in support of scientific and military activities in high Arctic latitudes. Their ability to land and take off on unprepared surfaces gives them a range of mobility comparable to that of a helicopter, and far in excess of that of the heavy aircraft normally used in polar regions. Their much greater range of flight enables them to be flown to high latitudes, whereas helicopters require to be transported to within a comparatively short distance of their objective. Low running costs are a further advantage where fuel has to be imported over long distances.

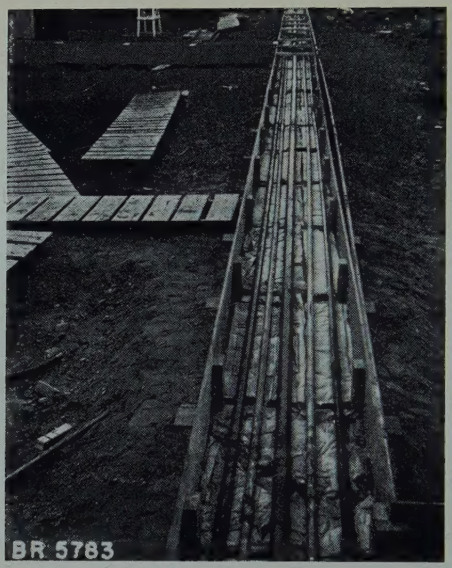
Piper Super-Cub aircraft landing on floats at 4000 ft on a glacier in north Ellesmere Island

Piper Super-Cub aircraft at Resolute Bay, Cornwallis Island

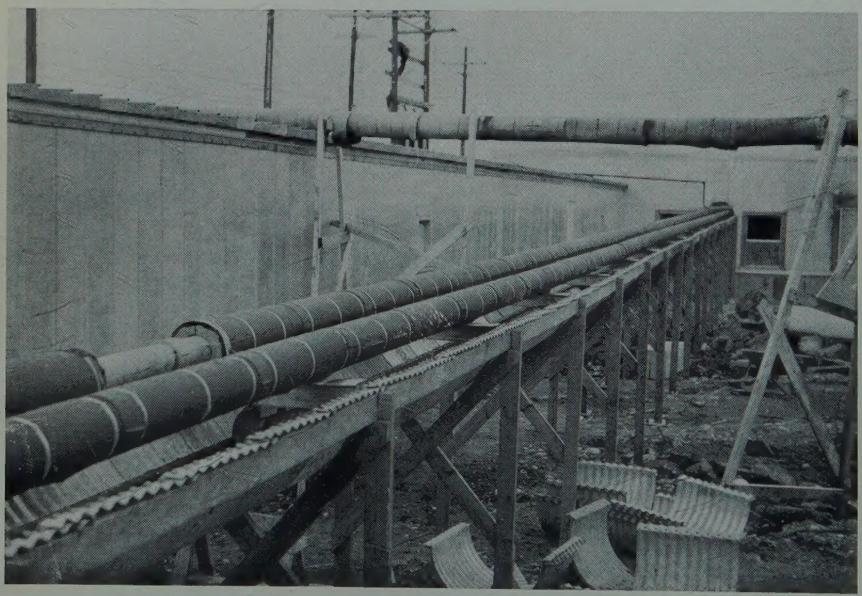
Use of light aircraft in high Arctic latitudes, 1958

Photographs by Terris Moore

(*Facing p.* 420)



Utilidor laid on ground surface



Utilidor raised above ground surface

(*Facing p.* 421)

WATER SUPPLY AND SEWAGE DISPOSAL IN PERMAFROST AREAS OF NORTHERN CANADA

BY H. B. DICKENS*

[*MS. received 10 September 1958.*]

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Introduction

Although the principles of water supply and sewage disposal in the north of Canada are the same as those for more temperate regions, the physical features of the installations often vary with the influence of low temperature and permafrost. These not only create technical problems of design but, when coupled with the relative isolation of most northern sites, they also introduce serious economic considerations. Operating costs as well as initial construction costs are higher, making facilities of the kind normally provided too expensive for many people.

Water supplies

Sources. Permafrost increases the problem of locating suitable water supplies by restricting the movement and the use of ground water as a source. Ground water may exist above (suprapermafrost water), within (intrapermafrost water) or below (subpermafrost water), the permafrost layer. Suprapermafrost water is not usually available throughout the year in regions where the seasonal frost extends to the top of the permafrost. In more southerly areas, where some thawed ground remains above the permafrost all year round, sources of suprapermafrost water may be found. Such supplies, however, are generally limited in quantity and of doubtful quality, since they are rarely more than 20 ft. (6 m.) deep and receive their water from the contamination zone of the subsoil. Intrapermafrost water rarely provides a suitable supply, and is likely to vary greatly in quality and safety.

Although subpermafrost water appears to offer the most promising means of continuous water supply, these sources are difficult to locate and costly to develop, particularly in areas where the permafrost is relatively deep. In many cases they contain large amounts of organic matter and objectionable quantities of iron and manganese.

* National Research Council, Canada, Division of Building Research.

Wells have been drilled successfully through permafrost but they pose special problems and are costly. Operation of wells in permafrost also presents difficulties. It is often necessary to provide controlled continuous pumping or to supply auxiliary heat in some form in order to prevent freezing. Too much pumping of wells in permafrost can in itself create freezing difficulties by depleting the total quantity of water in the well to such an extent that encroachment of the surrounding permafrost begins to occur.

Year round supplies of surface water are sufficiently scarce in permafrost regions for their availability and extent to govern the location of communities and determine the future development of a region. This statement may come as a surprise to some who have flown over these vast northern areas in summer and seen the myriads of ponds and lakes that dot the landscape. These small ponds and lakes are generally the result of retarded drainage due to the impermeable nature of the permafrost below; they are usually so shallow that they become completely frozen in winter. Bodies of water must be more than 8 to 10 ft. (2 to 3 m.) deep in such areas before they can be expected to provide some water in liquid form throughout the year. Ice cover rarely exceeds 8 ft. but it has considerable effect on the storage quantity of water in a lake. In addition, the mineral and organic content of the lake tends to concentrate in the unfrozen water below the ice, and may make it unsuitable for domestic use. A thorough study of lake depths, temperatures and related geological features is of vital importance before a water source is selected.

There are comparatively few rivers large enough to maintain an appreciable flow throughout the year, and utilization of water from rivers in the permafrost region is complicated not only by such bodies freezing solid in some places, but also by the formation of frazil and anchor ice at water intakes. Clogging of intakes with ice can be minimized by ensuring a deep pool of water over the intake and maintaining low intake velocities. Auxiliary heating facilities, using steam or electricity, may be provided to maintain the small temperature rise necessary to prevent icing of the intake structure. Care must be taken to protect the intake structure from damage due to movement of heavy ice masses during spring break-up.

Rainfall is so small throughout much of the Arctic that it is impractical to rely upon cisterns as a source of water supply.

The principal source of water supply used by the natives is melted snow and ice. Ice is cut from fresh water lakes or rivers in the fall when it is about 10 to 12 in. (25 to 30 cm.) thick and stored in a permafrost cellar or stacked on the ground. Special melting tanks equipped with steam coils have been provided in some of the larger buildings, but in the majority of homes ice is melted in a container in the building. High costs of fuel and the labour make such a method impractical for obtaining large quantities of water such as are required to serve a community. It would require the melting of 30 to 35 cu.ft. (0·8 to 1 cu.m.) of snow to provide 15 gallons (67·5 l.) of water per person per day, a figure generally considered a minimum for adequate drinking, cooking, bathing and laundering purposes. It is not surprising that the northerner

occasionally develops an immunity to bathing and, in some areas, keeps his use of water down to only two gallons per day.

During the summer months water for household use is usually obtained from fresh-water lakes or rivers, sources which may introduce health hazards by subjecting the water to undesirable handling and possible contamination. It is such practices, coupled with the general lack of water treatment and sewage disposal facilities, that have produced the most critical sanitary problems of the north.

Treatment. Low temperatures and permafrost do not in themselves reduce the occurrence of diseases associated with filthy conditions or faulty waste disposal methods. The quality of the water may change materially with the seasons but some degree of water treatment is generally required. In water sources subject to run-off, such as the large rivers of the Yukon and Northwest Territories, turbidity becomes a major problem at certain periods of the year. The Slave and Hay Rivers which run into Great Slave Lake carry with them considerable silt from break-up in early May until late summer, and the Hay River in particular carries sufficient organic matter to colour the water brown or greenish. Filtration is considered necessary during both spring and summer and chlorination is always necessary.

Many small shallow lakes develop an unpleasant taste and smell caused by concentration of organic and mineral content as the water depth decreases. In Lake Isabelle, which provides the water for Churchill, copper sulphate has to be used periodically during the summer months to control algae, and activated carbon to control taste and smell.

A major consideration in the treatment of northern water supplies is their low temperature. It is not uncommon to find both ground and surface sources at temperatures only slightly above 32° F. (0° C.) during the winter, although ground water from deep wells below the permafrost may be warmer.

Aeration, filtration, sedimentation, mixing of chemicals and chemical action all take place at a slower rate at low temperatures because of changes in the physical, chemical and biological properties of the water. This generally means that the time of mixing and aeration and similar operations must be increased, capacities of sedimentation chambers must be made larger and chemicals added in greater quantities. For instance, difficulties are experienced with gaseous chlorine apparatus due to the formation of chlorine hydrate crystals at temperatures below 50° F. (10° C.).

These factors suggest that it may be desirable to raise the temperature of the raw water prior to treatment. The question is really one of balancing cost of auxiliary heat against increased cost of treating low-temperature water. The possible savings in operating costs that may be effected by the right combination of conditions during treatment also suggest that experiments should be carried out on chemical dosage, flocculation and settling over a wider range of conditions to determine the most economical method of obtaining satisfactory treatment.

In small water systems, where seasonal turbidities are the only problem, diatomaceous-earth filters offer a useful alternative to orthodox coagulation

and filtration processes. Their initial cost is said to be much less and their operation simplified.[1] One northern community, the old Aklavik, has used these filters successfully for its summer water system.

Simple but rugged equipment is important because of the isolation of many communities and the difficulty of obtaining replacement parts. "Gadgetry" should be avoided.

All equipment and processes must be properly housed, insulated, and protected against low temperatures. Serious condensation problems can occur in buildings housing treatment facilities due to the tendency towards high humidities through evaporation from the several water surfaces in the plant. These problems must be controlled by proper attention to insulation and vapour barrier details in both design and construction of the facilities, and by provision of adequate ventilation during operation. Waterworks buildings must be built so as not to thaw the permafrost and must be protected against frost action in the active layer. These impose considerations not only of design but also of cost.

Distribution. The most common methods of delivery of water are by sledge and barrel or by tank truck. Such methods afford many opportunities for contamination of supply, and water obtained in this way may still be quite costly.

Some communities, such as the old Aklavik, have installed a pipe distribution system for summer use only, by laying pipes directly on the surface of the ground. During the winter months such a system must be dismantled and drained. Here again, there exists a real danger of contamination, particularly where the pipes are not picked up and stored in winter but are simply disconnected and left lying on the ground until the following summer.

Where permanent distribution by pipes is provided, the pipes cannot be laid below frost level because of the presence of permafrost, and sufficient heat must be available to prevent freezing of the water during distribution. If the heat naturally present in the water is inadequate to replace the heat losses from the system under normal conditions of operation, then freezing must be prevented by incorporating one or both of the following modifications: (i) by supplying heat to the water, or, (ii) by maintaining continuous water circulation.

If heat is supplied to the water, it may be added either at the source, or in the distribution system.

Water can be heated at the source either by steam, or hot water boilers, or electric heaters. Wherever possible, waste heat from other facilities, such as heating or power plant energy sources, should be used.

Heating of the water in the distribution system may be accomplished by enclosing the water line with other heat sources in a conduit or "utilidor"[2,3] (see photographs p. 421). Utilidors are enclosures of concrete, wood or metal, often insulated. They may be built to carry several services including steam, water, sewer, telephone and power lines or only one or two. The heat source may be steam or hot water central heating lines, where these are to form part of the community installation (as in the case in Inuvik) or a special steam tracer line may be placed alongside the water main. Utilidors range in size

from those large enough to walk through, and thus allow maintenance from inside, to those of only sufficient size to carry the utility lines. Access to the smaller ones is provided through a removable top. Well-designed utilidors greatly simplify the continuous distribution of water in low-temperature areas, but at a high cost; in addition to their high initial cost, there are operational hazards. With both water and sewer lines placed in the same duct there is the danger that leakage of sewage may contaminate the water supply. To reduce this possibility, the water line should always be kept above the sewer line and adequate drainage of the utilidor provided. Drainage constitutes a major problem with underground utilidors, since they must be made watertight to resist seepage of ground water. One method of handling this difficulty is to drain all such water to sumps at low points in the utilidor and to empty these sumps periodically by pumping to the sewer.

Preservation of the permafrost and prevention of frost heaving in the active layer must be given careful consideration. With utilidors containing central heating lines, the problem of thawing of the permafrost is greater due to their increased heat load. In areas of gravel or coarse sand, where little ice exists, few if any difficulties are experienced, since thawing of these materials does not usually produce any significant change in their properties. However, in fine-grained soils or organic material with high ice content, considerable settlement is likely to occur on thawing, resulting in differential movement of the utilidor and creating problems of alignment and groundwater seepage. In such conditions, an accepted method of construction is to support the utilidor on piling, steamed into the permafrost. Use of the pile method of construction permits the utilidor to be located completely above grade, leaving an air space between the bottom of the structure and the ground surface, thus reducing heat transfer to the frozen soil. In some cases, utilidors are placed directly on the ground, after first removing unstable material to some depth and backfilling to the level of the utilidor with soil not susceptible to frost action. In another method the permafrost is left undisturbed and a gravel mat at least 2 ft. (0·6 m.) thick is placed on the ground surface with the utilidor laid directly upon it. Local conditions will of course govern the choice of construction method but, in general, unless the active zone and the underlying permafrost are in well-drained non-frost-active material for a considerable depth, the above-grade system of construction is probably the most satisfactory.

Although heating of water at the source has been suggested as a means of avoiding freezing in northern water systems, the problem can rarely be overcome economically by this means alone. The water begins to lose heat as soon as it leaves the water plant and it is simply a matter of time before its temperature is lowered to 32° F. (0° C.). To make this system practicable, methods of continuous water circulation have been developed in which the unused portion of the supply is returned to the treatment plant for further heating and recirculation. These systems are of two main types—a dual main system consisting of a two-pipe service with high-pressure supply line and low-pressure return line laid side by side, and a single main service in which one pipe serves as

both distribution and return main, and is laid to form a closed loop beginning and ending at the circulation pumps.

A comparison of costs at the time the Fairbanks system was designed in 1953 showed that a single main system to serve this town would be $900,000 less than a dual main system. A similar comparison for Uranium City in 1957 estimated the cost of the distribution portion of a single main system to be $107,000 cheaper than that of a dual main system.

A preheated recirculating water distribution system arranged to make the most efficient use of all the available heat affords the most economical solution to water distribution in many instances, but such a system is also not without its problems of design and operation.

Service connexions. Service connexions to individual premises are usually the most frost-susceptible part of a water system. With a dual main system it is relatively simple to provide circulation of water through each service connexion. A drilled plate is inserted at the junction of the supply and return piping within the building to restrict the amount of water circulated and to ensure sufficient pressure differential between the supply and return mains.

In the single main systems circulation through the service connexion is protected by use of a "thermal tap".[2] The method is based on the principle used for maintaining circulation in single-pipe hot water heating systems. A further method depends on the use of the velocity head in the supply main, aided by special orifices, to maintain flow in the service connexions.

Alternatively, a very small pump in the supply line to each building can be used to keep water in the service connexion circulating. Where recirculation back to the main is not feasible the service connexion may be protected by means of a heated utilidor enclosing the service connexion from the main to the building, or an electric resistance heating unit attached to the service pipe. A continuous flow may be obtained by wasting water through open house taps, or by a device installed on a water tap to permit controlled continuous leakage to the sewer.

Considerations of design. In laying out a distribution system, there are a number of considerations that should be kept in mind to achieve maximum economy and minimum operating trouble.

Dead ends should be avoided and the system arranged so that the largest users are located at points furthest from the treatment plant. The cost of insulating water lines must be balanced against the increased cost of heating if the lines are left uninsulated. Consideration should be given to the use of cheap local insulating materials such as peat and moss. Studies carried out on the Yellowknife water system in which moss was used around the pipes as insulation, suggest that it is of little value when used below grade unless it can be kept dry.[4] Wet moss is not a good thermal insulator; when present at the surface, it protects the permafrost through the mechanism of evaporation, but, when placed around pipes, this process cannot take place and its insulating value is therefore reduced.

Fuel is expensive and only just sufficient heat should be added to the water to prevent freezing. Owing to the complex nature of heat losses from a

circulating water system, the temperature to which the supply water must be heated to achieve this condition is difficult to determine except by trial when the system is in operation. It should be noted, however, that the temperature of the return water when it reaches the treatment plant provides only a relative indication of the freezing hazards in the system, since it is quite possible for this return water to be several degrees above 32° F. (0° C.) and yet some part of the water supply still be in danger of freezing. In the Yellowknife system, for example, it has been found that the return water has to be kept at about 41° F. (5° C.) to prevent freezing in some remote part of the system during the coldest periods.

The temperature of the source water is also an important factor in the overall economy of any system, since an increase of a few degrees at the source can effect a considerable saving in the heating bill. For this reason, advantage should be taken of the thermal anticlines that exist in lakes during the cooling cycle. Because the density of the water is at its maximum at 39·2° F. (4° C.) very little convection takes place as the water cools below this temperature and it is therefore possible to obtain water close to 39° F. near the bottom of the lake for some time after the water at the surface has cooled several degrees below this. The advantage of obtaining warmer water is sufficiently great to justify some expenditure for this purpose, as is the case in the newly designed water system at Whitehorse. Here, wells have been drilled to supplement water obtained from the river, the temperature of this well water being several degrees above that of the river water.

Finally, whichever system of water distribution is selected, the question arises whether to place the pipes above or below grade. The condition of the soil in the area and the difficulties that may arise from frost action in the active layer or from melting of the permafrost are probably the most important factors in this decision. If these conditions do not prohibit placing the services below grade, then the question of construction cost plus heat loss becomes important. If the system is placed in the ground it may be located in permafrost or in the seasonally frozen layer. If it is placed in the seasonally frozen layer it will experience lower temperatures during the winter than it would in permafrost. If placed in permafrost it will remain below freezing point throughout the year. An important factor is of course the work required to excavate for buried lines.

Soviet engineers are reported to prefer laying water supply pipes in the ground to depths of 10 ft. (3 m.) at which depth temperature fluctuations are insignificant and the temperature remains only a few degrees below freezing. A layer of gravel and sand is placed around the pipes and the pipes surrounded for a distance of two diameters by loose earth. The moisture retained in this soil is intended to retard frost penetration. Sand and gravel are then placed around this loose earth and covered from above by a layer of dried peat approximately 8 in. (20 cm.) thick. Although not stated, it would seem that such practice would be more suited to sporadic permafrost areas than to continuous, because of the difficulty and high cost of excavating to those depths where the permafrost is close to the ground surface.

Sewage

Individual systems. In most communities, the primitive pail system, or modifications of it, is the common method of sewage collection, the wastes being dumped on the tundra or into nearby water courses. The dumping may be done by the householder or occasionally, in larger communities, by a contractor. Final disposal of sewage by this means is not always controlled and may lead to the creation of offensive and insanitary conditions over the entire disposal area, as well as to the pollution of local water supplies.

The chemical toilet offers some advantage over the simple pail receptacle, providing the chemicals are added when required, but these units are not used extensively due probably to the cost of the chemicals.

Septic tanks have been used with only limited success. Some tanks have relied on auxiliary heating to prevent freezing and to maintain temperatures at which satisfactory bacterial action will take place. Others have depended solely on insulation. The most satisfactory have been those placed in a heated building. Studies on septic tanks carried out at the Arctic Health Research Center in Anchorage, Alaska[5] suggest that such tanks can operate satisfactorily in sub-arctic areas over a winter period without the use of heat simply by utilizing undisturbed snow cover as insulation. The disposal of the effluent from a septic tank still presents a problem, however, since disease-causing bacteria are not destroyed in the tank.

Community systems. Very few water-carried community sewage collection systems have been installed in permafrost areas. This is due in part to the lack of water, but an important contributory factor is the problem and expense of combating low temperature, frost action, and permafrost.

Community systems have been in use at Flin Flon since 1932, at Fairbanks since 1939 and at Yellowknife since 1949.

The system at Flin Flon utilizes wood stave pipe, a large part of which is located with less than 3 ft. (1 m.) of cover, due to rock formation in the area and is placed in wooden boxes containing heated water-mains, the entire assembly insulated with wood shavings. Freezing difficulties with this system are generally related to flow obstruction arising from frost heaving and differential settling which produces low spots in the lines, or to low flow where only small quantities of water are used in the building serviced.

At Fairbanks also wood stave pipes were used with many of the lines having only 3 ft. of cover and an unusual number of dead ends in the system. Shortly after being put into operation, this system began to experience difficulty due to misalignment because of melting of the permafrost, and clogging from freezing brought about by insufficient flow and lack of soil cover. In 1949 work on the rebuilding of this system was started. The Arctic Health Research Center has studied the use of automatic flushing wells to maintain sewers in operative condition using ground water at only 33° F.(−5·5° C.). The addition of such water to the sewers at the rate of 500 gallons (2250 l.) per hour, from 100-gallon flush tanks, has greatly reduced the freezing problem and

it has even been possible by this means to thaw a sewer partially filled with ice.

At Yellowknife, the collection system consists of a corrugated steel pipe laid in the ground with a minimum cover of 7½ ft. (2·3 m.) and located 2 ft. (0·7 m.) below and 6 ft. (2 m.) horizontally, from the water-mains. Moss was placed around the pipes during construction as insulation, but no auxiliary heat was added to the sewer during operation. Underdrains were placed below the sewers to carry off ground water and to improve the insulating properties of the moss.

Experience with these various systems has shown that collecting-sewers, like water-lines, can be kept operative only if they are protected from freezing and from differential movement due to frost action in the active layer, or to melting of the permafrost.

Enclosing the sewer in a heated conduit or utilidor is probably the most positive way of ensuring trouble-free operation, but such installations are expensive to construct. The importance of economy in community sanitary installations suggests a preference for systems in which the pipes can be placed directly in the ground.

When water systems are installed without heated utilidors they require heating and circulation of the water to function properly. Sewers are somewhat less vulnerable as the sewage contains warm waste water from heated buildings. This additional heat may be sufficient to allow the sewer to function satisfactorily without insulation or auxiliary heat, particularly if the sewer pipes can be laid at depths where the soil temperatures are only a few degrees below freezing, and do not fluctuate very much throughout the year. Rock outcrops, frost-active soil and permanently frozen ground with high ice contents must be given careful consideration in design.

Where ground conditions are such that buried pipes can be considered, various precautions may be taken to preserve heat and protect against freezing. The sewer lines should be located where advantage can be taken of solar radiation and of the insulating effects of snow cover and vegetation. They should not be placed under the travelled section of roads where little insulating cover is available and where they are subject to damage from compaction of soil above them.

There are instances where the thermal properties of the pipe itself are significant. One example is a short run of outfall sewage line subject to intermittent discharge of sewage by siphon from a heated building, where the quantity of heat required to warm the pipe, as represented by specific heat and density of the material, is an important factor. Analysis in this case showed that differences between the thermal characteristics of thin-walled aluminum and thick-walled cast iron pipe were important.

It has been noted that sewers have frozen even when the adjacent ground temperatures were themselves above freezing, due to the tendency of very cold air to flow downward through the sewer vent and displace warm air in the sewer. The plumes of frost that form on house vents provide visual evidence of a secondary aspect of this problem (the blocking of house vents by frost)

and one which can itself create difficulties. Some method of control of air flow within the vent stack may be required to limit the heat exchange that can occur by this means.

Treatment. The effectiveness and safety of most methods of sewage disposal are greatly impaired by low temperature and the presence of permafrost. The processes of assimilation and decomposition of wastes that occur in soils in temperate regions do not appear to take place at all in permanently frozen ground, and only very slowly in the shallow top layers of seasonally thawed ground. Thus the normal methods of sewage disposal in the soil, including the use of leaching pits, septic tank disposal fields, and the pit privy, cannot be readily practised in northern regions. Since a large percentage of the present population must rely on individual household disposal, this limitation is a serious one.

Yellowknife is the only community in the Northwest Territories that provides much in the way of treatment of its sewage wastes; most communities discharge their raw sewage with little or no treatment directly into nearby water courses or tidal waters. The problem of stream pollution is complicated by the low temperatures of surface water which tend to slow biochemical reactions and reduce bacterial die-away rates so that less reliance can be placed on natural self-purification of effluents in the receiving waters. As the population increases, the discharge of raw sewage into natural water courses will become a more significant health matter and the need for treatment facilities more pronounced.

Experience with the design and operation of both primary and secondary sewage treatment processes in regions of low temperature has been summarized by Thomas[6] and by Clark;[7] but many questions remain unanswered.

Two recent developments in treatment of sewage hold particular promise for northern use. The first is the process of sewage lagooning.[8] This method of treatment consists of discharging raw sewage into large shallow lagoons, or oxidation ponds, where aerobic conditions are maintained and natural decomposition takes place. Sewage lagoons provide for biological or secondary treatment of sewage and, if properly constructed, they will provide a high degree of treatment approaching that in most of the more expensive treatment plants.

Lagoons appear to work satisfactorily in cold climates. In winter months the effectiveness of the lagoon is reduced, but even during this period a biochemical oxygen demand reduction of 65 per cent has been obtained, as compared with 85 to 95 per cent in summer. The lagoon depth should not exceed 3 to 5 ft. (1 to 2 m.) to ensure aerobic conditions and eliminate smells. In cold climates, depths greater than this must be provided to allow for ice cover, and it may be desirable in such areas to provide some form of control that will permit the lagoon to operate at shallower depths during the summer.

The main advantages of lagoons are that both initial and operating costs are less than for conventional plants and the effluent is normally in a stable condition.

The principal disadvantage associated with this method is the large area of land required for construction of the lagoon. One acre (4047 sq.m.) for

one hundred persons is normally recommended, based on experience in areas with an evaporation loss of 18 in. (46 cm.) per year and percolation rates through the soil of $\frac{1}{8}$ in. to $\frac{1}{4}$ in. (0·3 to 0·6 cm.) per day. In areas in which evaporation and percolation are likely to be less, larger lagoon areas may be required.

An important consideration with lagoons in permafrost regions would appear to be the danger of using areas where the soil has a high ice content and where melting of the permafrost can cause settlement. Under these conditions, the dykes may wash out and allow seepage of sewage wastes into the surrounding area.

A second recent development is one in which the sewage is collected and subjected to aerobic digestion in a tank located in a building. This system is essentially a biological oxidation process, using a modified activated sludge treatment, and is reported to be capable of providing a degree of treatment which compares favourably with that obtained in a conventional plant. The essential parts of the system, in addition to the tank, are a compressor to aerate the sewage and a circulating pump to flush the toilet mechanism. A grinder type toilet is used to prepare the sewage solids for more effective treatment by aeration. The grinder can be operated electrically or by the pressure of water during flushing. An important advantage of this method is the possibility of operating the unit as a closed system handling toilet wastes only, and without any discharge of effluent to the outside. Treated effluent from the tanks serves as the flushing medium, being simply recirculated through the toilet bowl and back to the tank by a small circulating pump. Other household wastes from bathroom and kitchen can be connected to the treatment tank, if desired, but this means operating the system as an open unit and raises the problem of discharging sewage containing human waste to a suitable disposal area. With the closed system, the only material requiring disposal from the tank is the sludge that may accumulate after prolonged periods of operation. Initial studies suggest that this accumulation of sludge is small. Advantages offered by this system are a potentially high degree of treatment, and savings in water resulting from the use of the effluent for toilet flushing. Initial and operating costs are at present not low but are comparatively so, when considered in relation to the degree of treatment that may be achieved. Further studies appear necessary with respect to the effect of tank size, aeration rate and population load, before rational design can be attempted. Research of this nature is now under way in Canada under the auspices of the Central Mortgage and Housing Corporation, the country's national housing agency.

Summary

Although low temperature and permafrost complicate the provision of sanitary facilities they have not altogether prevented the construction of workable sewage and water systems, but they have seriously increased their cost. Experience with existing installations has demonstrated that the sanitary engineering practices of more temperate regions must be modified

to suit the special climate and soil conditions of the north. In providing adequate economic sanitary control in these fast developing northern regions, the engineer is faced with one of his most challenging tasks.

Acknowledgements

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SKIN DIVING IN POLAR WATERS

BY COMMANDER FRANCIS D. FANE, U.S.N.R.

[*MS. received 22 July 1958.*]

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Introduction

For some years members of the Underwater Demolition Teams of the United States Navy have been carrying out experiments in skin-diving in Arctic and Antarctic waters, with the object of determining the limits of man's endurance in these conditions. The main military purposes of swimming in polar waters are to assist the escape of ships beset in ice by blasting channels out to open water, and to reconnoitre landing beaches which are protected by ice. Secondary operations include inspection and repair of under-water damage to ships and the recovery of submerged equipment.

Tolerance to cold

It has been proved that, properly protected, man can work for considerable periods in water temperatures as low as 29° F. (−1·6° C.). This is demonstrated in the following extract from the log of an Underwater Demolition Team operating off Kodiak, Alaska.

"*a.* The reconnaissance was conducted by 26 swimmers. The water temperature was 36° F. (2° C.). Slush and ice were encountered near the beach which probably lowered the temperature 3° to 5°.

b. The average time spent in the water was 55 minutes, with the maximum 1 hour 50 minutes, and the minimum 20 minutes. The swimmers covered distances of $\frac{1}{2}$ to $1\frac{1}{4}$ miles.

c. The average body temperature of swimmers returning to the ship was 93° F. (34° C.) with an average time of 30 minutes required for temperatures to return to normal. This was aided by supervised shower baths, starting with cold water increasing to room temperature, about 70° F. (21° C.). All swimmers suffered from chilling of the hands and feet".

Big, heavily-set men often show more tolerance to cold water than the lean wiry type, but the individual range of tolerance is too great for generalizations to be made. Training records show that the following reactions can be expected at the various sea temperatures:

80° to 90° F. (27° to 32° C.). Prolonged swim periods of 4 to 6 hours daily for months on end can be conducted with no protective clothing.

70° to 80° F. (21° to 27° C.). Swim periods of 2 to 4 hours are normal.

Small loss of body heat occurs. In the lower temperatures range, chilling will occur after 2 hours.

60° to 70° F. (16° to 21° C.). The body feels the cold on first entering the water. Men warm up after exercise and can swim from 1 to 2 hours without protection. However, shivering is noticeable on coming out of the water. Some retention of body heat can be obtained by wearing a suit of underwear. Some swimmers will require protective swim suits in these temperatures. A permeable or "wet" suit is recommended.

50° to 60° F. (10° to 16° C.). Swim suits are required for all swimmers. The "wet" suit provides quite satisfactory protection in this temperature range. Swims of 2 to 4 hours can be conducted without excessive body heat loss, but chilling will be experienced.

40° to 50° F. (4° to 10° C.). An impermeable or "dry" swim suit, with one suit of "waffle weave" nylon underwear, heavy wool socks, gloves, and head piece are required. Swims of $1\frac{1}{2}$ to $2\frac{1}{2}$ hours duration are possible. Hands and feet will become progressively colder and some discomfort will be felt in the later stages of the swim. Men will shiver after leaving the water. Body temperatures will drop 2° to 3° F. Some swimmers are capable of using "wet" suits in this temperate range if air temperatures are above freezing.

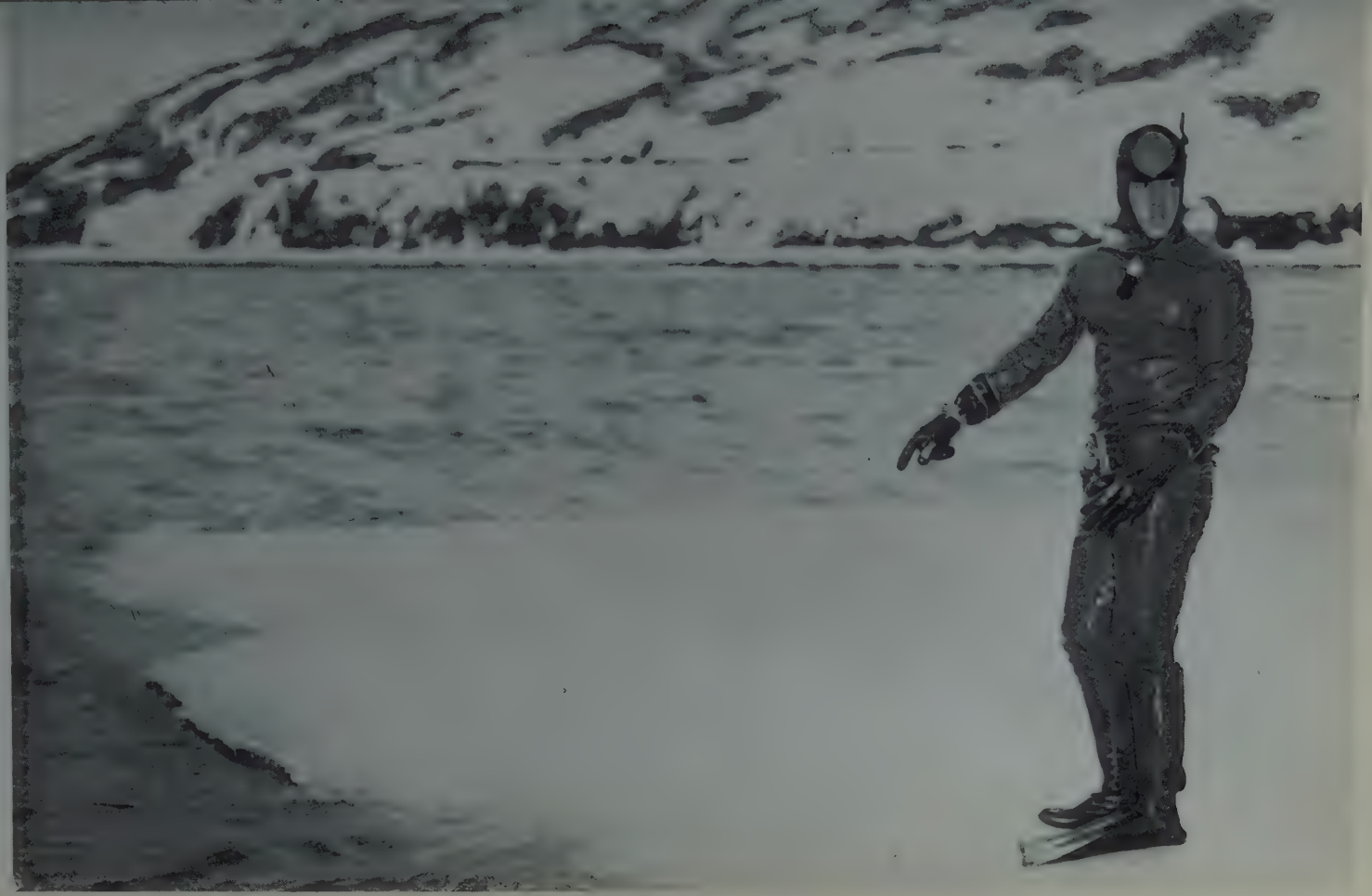
28° to 40° F. (−2° to 4° C.). "Dry" suits and double suits of undergarments, socks, gloves and heavy head pieces are required. Ensolite (polyvinylchloride) underwear has been used with success, though the initial buoyancy of the diver is increased, requiring about 12 lb. additional weight to achieve neutral. Due to pressure, the buoyancy decreases sharply at depths of 20 ft. (6 m.). In dives of over 100 ft., it may be necessary to drop weight. Swimmers will feel the cold, but can be expected to endure immersion for a period of 1 hour. The extremities may numb, and cold will be felt in the mouth and where facial tissue is exposed. Any leakage in suits will result in immediate chilling and usually terminate the dive. If shivering occurs while submerged, divers should immediately leave the water. Body heat loss of 3° to 5° F. can be expected. Divers who show the effects of cold, should be given warm showers or baths, gradually increasing the heat, then placed under warm blankets until body heat returns to normal.

Protective clothing

The proper fitting of swim-suits is of vital importance, and particular care should be taken with the fit at neck, wrists and ankles to avoid "binding" and restriction of circulation by too close a fit. "Wet" suits are made to the personal measurements of each member of the Underwater Demolition Teams, while "dry" suits are supplied in four fittings.

"*Wet*" *suits.* These are made of unicellular foam plastic material (polyvinylchloride) and are easier to put on, to swim in, and to repair than "dry" suits. They are close fitting and therefore allow very little circulation of water next to the skin. This water is warmed to near body temperature while the foam cells act as insulators, retarding loss of body-heat to the surrounding water.

"*Dry*" *suits.* These are made of water tight rubber, or rubberised fabric



(*Facing p. 434*)

Skin diving in polar waters

Photograph by Amphibious Training Command, U.S. Pacific Fleet

Tractor train of A.N.A.R.E. seismic party, Mac-Robertson Land, 1957–58

(*Facing p.* 435)

and are worn with one or more sets of undergarments. Nylon "waffle-weave" underwear is more satisfactory than wool for this purpose, and two pairs of this underwear will provide adequate comfort for 45 to 60 min. in a water temperature of 40° F. (4° C.). Separate gloves are recommended; they can be sealed to the sleeves by overlapping on a rigid bracelet and bound with adhesive tape. One pair of nylon and one pair of woollen gloves are sufficient for most temperatures. The feet are the most difficult part of the body to keep warm and the most satisfactory covering was found to be a pair of thermolyte (heavy pliable plastic socks), with the rubber foot of the swim suit as a third cover. In this combination feet will retain warmth for about an hour in temperatures of 40° F. A head covering consisting of a hood of polyvinychloride material worn under the swim suit will provide sufficient warmth. In these conditions, a face mask is worn covering the eyes and nose and exposing only the mouth.

Breathing apparatus

The "aqua-lung", air-type, breathing apparatus is recommended. No special modifications have been found necessary in polar waters, though the diaphragms should be checked in very cold air temperatures as the rubber may freeze.

AUSTRALIAN ANTARCTIC ICE THICKNESS MEASUREMENTS AND SASTRUGI OBSERVATIONS, MAC-ROBERTSON LAND, 1957–58*

BY K. B. MATHER† AND M. J. GOODSPEED‡

[*MS. received 5 December 1958.*]

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Introduction

The principal field activity of the A.N.A.R.E. party at Mawson during the 1957–58 summer was the determination of ice thickness along a section of the Antarctic plateau. In previous years the summer expeditions inland had concentrated on the survey and geology of the Prince Charles Mountains, south-east of Mawson. While this programme was continued in 1957–58 as opportunity presented, and in fact air photography of the ranges almost completed, the main I.G.Y. field effort was directed towards seismic ice-depth determinations. These were the responsibility of the Bureau of Mineral Resources, and a seismologist was seconded to the Antarctic Division, together with equipment for the purpose.

The traverse made lay southwards from Mawson, following approximately the meridian 62° 08′ E. It was known from prior air reconnaissance that a south-westerly spur of the Prince Charles Mountains system cut across the route in the vicinity of lat. 73° to 74° S., but the exact location was unknown. The intention was to map this spur, then skirt it to the west and resume the seismic traverse southwards.

Apart from seismic profiling and related gravity and altitude measurements, other projects scheduled for the southern journey included glaciological observations,[1] magnetic variation measurements, and regular surface and upper air meteorology.

Equipment

Transport consisted of two tractor trains, each of five sledges drawn by a 6-ton 'Caterpillar' D4 tractor. The tractors were provided with snow tracks 24 in. (61 cm.) wide to which were bolted steel grousers (12 on each track) to prevent slide-slipping on hard coastal ice. The tractors pulled 13 tons each

* Published by permission of the Director, Bureau of Mineral Resources, Department of National Resources, Commonwealth of Australia.

† Physicist-in-Charge, Mawson, 1957.

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and, apart from a tendency to become bogged in soft snow patches far inland—which may have been due to faulty sledge design rather than inadequate track width—performed well. No serious mechanical troubles were experienced during more than 800 miles of plateau travel. Fuel consumption averaged 1 gallon per mile for each tractor, including that used in idling, bulldozing snow drifts, digging glaciological pits, and building marker cairns. Sufficient fuel for a journey of about 1100 miles was carried.

A Weasel was used as scout vehicle, operating about 5 miles (8 km.) ahead of the main trains. Early experience had shown the tractors to be vulnerable in crevassed terrain, hence every effort was made to establish a safe route before proceeding with the heavy vehicles. The proposed route had been examined thoroughly from the air during long reconnaissance flights in a De Havilland Beaver aircraft. The Weasel's function was to provide a second safeguard—to select a route and report back to the trains by radio at regular intervals. On the whole this worked well, although a few unpleasant incidents are probably inevitable on a long plateau journey.

A hydraulic drill with flight-auger rods, driven by a 25 h.p. diesel engine, was used to drill shot holes. Electric power for the seismic and other scientific equipment was available from a 1·5 kW. diesel generator.

Seismic equipment, consisting of a 12-channel Houston Technical Laboratories 7000-B amplifier set and a Technical Instruments Company oscillograph, was installed in an insulated cab together with radio transceiver and developing tanks. The cab, weighing about a ton, was spring-mounted on a sledge and fitted with thermostatically-controlled electrical heaters. Thus the equipment was protected against temperature variations and mechanical shock and little maintenance was needed, even though shocks due to uneven terrain were severe enough at one stage to break leaf springs supporting the cab.

The total weight of the trains, including vehicles and about 15 tons of fuel and lubricants, exceeded 40 tons.

All navigation was carried out from the Weasel, the trains merely following its tracks which remained clearly visible on the snow surface. Astro-compasses were fitted to the roof of the vehicle and a magnetic grid steering compass was mounted on the dashboard. An astrofix was secured at each seismic shot point. On the outward run snow cairns, 8 to 10 ft. (2·5 to 3 m.) high, were bulldozed at camp sites to serve as trail markers for the homeward run.

Traverse

The southern party consisted of six men: K. B. Mather, leader and physicist; M. J. Goodspeed, seismologist; N. J. Collins, mechanic; R. L. Willing, medical officer; M. M. Mellor, navigator and glaciologist and B. E. Shaw, radio operator.

The expedition left Mawson on 9 November 1957. The first section of the route had been explored during the year and was fairly well established, but the greater part was through previously unexplored territory. The main obstacles were steep gradients near the coast, sometimes requiring loads to

be relayed, and crevassing associated with the local ranges south of Mawson. The route was devious through this region (see Fig. 1), but after clearing the ranges the party struck due south along meridian 62° 08′ E. A 7 ft. crevasse broke under one tractor when 30 miles from Mawson but the train pulled across without loss.

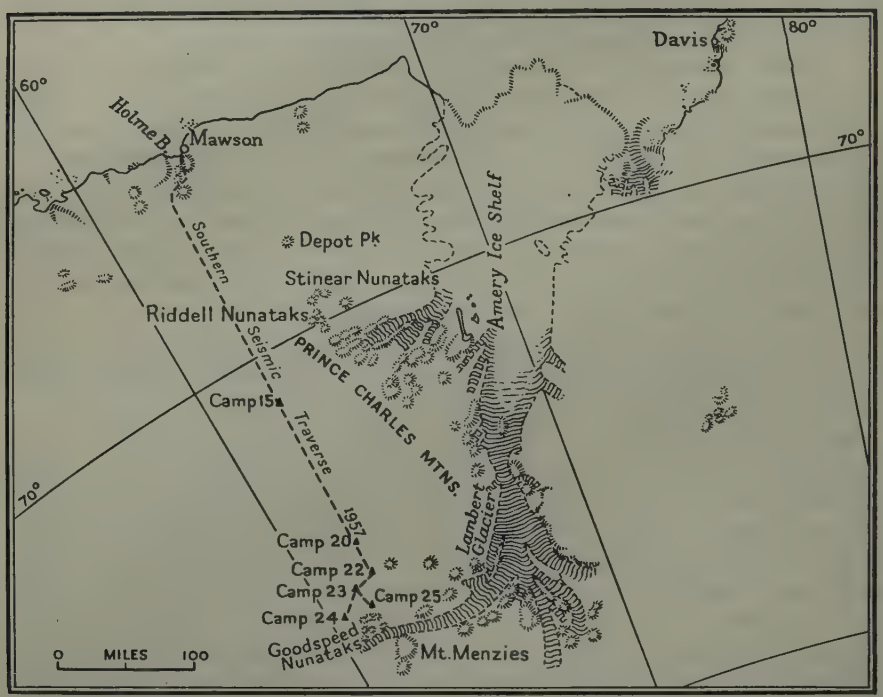

Fig. 1. Map showing route of seismic traverse, Mac-Robertson Land, 1957–58.

The first 100 miles (160 km.), to Camp 7, was characterized by hard, wind-packed snow surfaces and increasing roughness of sastrugi, the maximum height of which was then about 30 in. (76 cm.). A belt of ice domes, between about lat. 68° 30′ S., and lat. 68° 40′ S., though responsible for severe crevassing each side of the route, was traversed without incident. Seismic camps were established at regular intervals. The usual aim was to travel one day and spend the next shooting, but weather conditions, especially prolonged whiteouts, repeatedly disorganized plans. Camp 6, 88 miles from Mawson, was the scene of a severe blizzard which delayed operations for four days, and buried the trains in snow drifts.

Beyond Mile 140 (225 km.) the surface became softer in patches. Sledges were often awash with snow to their decking and tractors became bogged with increasing regularity.

The roughness of the plateau surface grew worse until about 180 miles (285 km.) from Mawson, where sastrugi were recorded 54 in. (137 cm.) high. Thereafter the heights of sastrugi diminished, rarely exceeding 25 in. (64 cm.)

for the next 130 miles (210 km.). Over most of the route vehicles pitched and rolled to an extent that demanded the use of safety belts by drivers.

The occurrence of surface "cracking", often associated with belts of ice domes but rarely leading to clearly defined crevasses, made a cautious approach necessary in several regions. On one occasion a 6-ton fuel sledge broke through a concealed crevasse with one runner and had to be winched out, but in general such zones were traversed safely.

Camp 22, at the end of the southerly course, and 358 miles (576 km.) from Mawson, was reached on 6 January 1958. By this time the major peaks of the south-westerly spur of the Prince Charles Mountains were clearly visible to the south and numerous ice domes occurred to the west. From this and subsequent camps during the south-westerly run the Weasel team, Mellor and Shaw, made sorties towards the ranges, partly while route-finding for the trains but also to survey the main features of the ranges. An astrofix was obtained on one of the Goodspeed Nunataks and geological samples were collected.

Attempts to by-pass the mountains on their western flanks, at Camp 24, and later to drive between massifs southwards, at Camp 25, both failed in the face of very severe crevassing. Camp 24, in lat. 72° 52′ S., long. 60° 26′ E., approached through valleys between ice domes, was the most southerly point reached by the expedition. The total length of seismic traverse, including the run from Camp 23 to Camp 25, exceeded 400 miles (643 km.).

The party returned to Mawson on 16 February 1958, after an absence of 100 days. Two tons of surplus fuel were dumped at Camp 16, in lat. 70° 49′ S., for the use of the 1958–59 summer party.

Throughout the journey, the weather was consistently bad. Snow drift was recorded on sixty-two days, while on thirty-eight days whiteout prevailed for all or most of the day. Due to strong morning winds, often interfering with seismic records and burying the geophone lines under snow, the party generally breakfasted about midday and worked through till 03·00 hr. Temperatures ranged from 20° to −30° F. (−7° to −35° C.) during the trip.

Ice thickness measurements

Ice thickness was measured by the seismic reflexion method at twenty-five stations along the traverse. Seismic velocities near the surface were studied at each of these stations and, at two places where the ice was close to its maximum depth, velocities at depth were determined by full-scale refraction methods.

The altitudes of each of the seismic stations and of points between them were measured barometrically. Two barometers were used, one being transported in the scout Weasel and the other on the main tractor train. The Weasel would advance about 5 miles ahead of the train and simultaneous air pressure and temperature readings would be made at the train and at the Weasel. Then the train would move up to the position previously occupied by the Weasel while the latter moved on another interval. In this way altitude differences were obtained to check the altitude of each point occupied.

Wherever altitude was measured a gravity reading was taken, using a Worden geodetic gravimeter read at ambient temperatures. The gravimeter was transported in a freely-sprung frame mounted outside one of the caravans.

Conventional seismic techniques were employed. Geophones were laid along two directions at right angles, so that the total dip of the rock surface could be determined, and were off-set about 500 ft. (152 m.) from the shot point to reduce interference from noise generated by the wind passing over the cab and other units of the trains. Charges, ranging from 4 oz. (0·1 kg.) to 5 lb. (2·3 kg.) of T.N.T. according to conditions, were detonated at the bottom of shot holes about 90 ft. (27 m.) deep. The holes were used for measuring temperature profiles prior to shooting.

Gravity measurements themselves do not allow direct ice depth computations, because of variations from causes other than ice depth, such as rock density changes and broad regional variations in gravity. However, with accurate depth measurements at the seismic stations, these effects can be allowed for and the ice depth at each of the intermediate gravity stations obtained.

Regional variations of gravity are of great interest in themselves and, since a gravity tie by aircraft was made earlier in the year between Mawson and a pendulum station at Mirnyy, it will be possible to put the gravity profile on an absolute basis.

The shallow velocity determinations are also of interest apart from their use in deriving ice depths. An attempt will be made to correlate these with temperature and density measurements.

A preliminary profile is shown in Fig. 2, and includes altitude and seismic ice depth measurements. Work is proceeding on the gravity results and also on the detailed study of reflexion records, some of which show further events below those from which depths have been computed—suggesting that the solid rock is overlain in places by moraine-like material.

The most conspicuous feature of the ice profile is the decline in altitude southwards from Mile 200. It appears that the general northerly flow of the ice from the centre of the continent is blocked off by the south-westerly spur of the Prince Charles Mountains which appear above the ice at Mount Menzies and associated nunataks. Further damming of ice flow by the submerged peak at Mile 175 is suggested by the banking up of ice behind it. This peak is some 50 miles west of the out-cropping Riddell Nunataks and is probably a submerged continuation of them.

The deep fjord-like ravine which was crossed at Mile 88 was measured in the centre of a very prominent belt of ice domes and depressions, suggesting that a belt of rugged rock topography was crossed here, although no rock outcrops occur in the vicinity.

Further discussion of the profile must await the addition of gravimetric determinations of ice depth. A more detailed account of the equipment and methods used is contained in Bureau of Mineral Resources Records No. 40, 1958 (unpublished).[2]

Sastrugi observations

Along most of the traverse sastrugi were sufficiently well developed and uniformly oriented to suggest making use of them as a measure of the katabatic wind direction, assuming, of course, that this does not change appreciably during the year. Table 1 lists the true bearings of sastrugi at various latitudes.

Table 1. *Orientation and height of sastrugi encountered during seismic traverse, Mac-Robertson Land, 1957–58*

Camp	Distance along traverse in miles	Latitude	Altitude of plateau ft. and (m.)	Bearing of maximum gradient (°True)	Bearing of sastrugi (°True)	Maximum height of sastrugi in. and (cm.)
Mawson	0	67° 36′	0	140	130–140	—
1	10	67° 44′	1410 (430)	—	—	—
2	25	67° 53′	2860 (875)	—	—	—
3	45	68° 07′	4300 (1310)	195	150±5	7 (18)
4	70	68° 25′	5410 (1650)	210	159±3	18 (45·5)
5	78	68° 33′	5760 (1755)	—	158±4	19·5 (49·5)
						30 (76) transit
6	88	68° 41′	5900 (1800)	210	161±4	—
7	101	68° 52′	6290 (1920)	—	—	—
8	109	68° 59′	6560 (2000)	—	158	—
9	129	69° 16′	6830 (2080)	230	168	34 (86)
10	134	69° 21′	7030 (2140)	—	172	—
						36 (91·5) transit
11	154	69° 37′	7840 (2385)	—	180	30 (76)
						42 (107) transit
12	174	69° 55′	8280 (2525)	240	185	—
						54 (137) transit
13	195	70° 13′	8470 (2580)	—	187	—
14	200	70° 18′	8680 (2645)	270	—	—
						18 (45·5) transit
15	216	70° 31′	8030 (2445)	—	204	21 (53)
						24 (61) transit
16	237	70° 49′	7990 (2435)	—	—	—
						36 (91·5) transit
17	258	71° 08′	7540 (2300)	290	210	26 (66)
18	273	71° 21′	7370 (2245)	—	—	—
						24 (61) transit
19	301	71° 46′	6810 (2080)	—	229	27 (68·5) fluctuating
20	333	72° 13′	6930 (2115)	280	222	27 (68·5)
21	343	72° 29′	6860 (2095)	—	228–2	—
						18 (45·5) transit
22	358	72° 36′	6640 (2025)	—	227–6	24 (61) fluctuating
23	378	72° 42′	7170 (2185)	—	222	36 (91·5) fluctuating
24	399	72° 52′	7750 (2365)	—	221	—
25	409	72° 51′	7070 (2155)	—	223	24 (61) 10 miles south of Camp 23

Note. Sastrugi heights given in the last column were measured during journeys between camps; "fluctuating" indicates that considerable variation in surface roughness was observed.

Bearings were taken with a prismatic compass and corrected for magnetic variation, which was also measured at each camp site. Ten or twenty readings were made at each site and the root-mean-square deviation of each group calculated. This ranged from 2° to 6°, which is much smaller than the swing which takes place in the average sastrugi direction, viz. from 150° near the

coast to about 225° at lat. 72·5° S. During the first 300 miles (480 km.) of traverse the sastrugi direction swung round at an average rate of about 0·3° per mile.

The effect can be interpreted fairly confidently in terms of plateau topography. The southerly course of the traverse approached close to the great drainage region of the Lambert Glacier. Comparison of barometric heights, measured along the traverse with those obtained previously further east, indicates that the altitude of the plateau falls away to the east of the traverse. This checks with the general picture obtained by setting up a theodolite at each camp and taking vertical angles made by the horizon at eight points of the compass. The plateau is generally higher to the west and declines eastwards of the traverse. One would therefore expect the katabatic wind to have a westerly component if it follows approximately the gradient of maximum slope. However, the Coriolis effect, which is likely to be comparable in magnitude, tends to give the wind an easterly component. The observed wind will be the resultant of these two influences.

Mawson station is situated on the east side of Holme Bay where the coast and contour lines of the plateau are oriented approximately 50° E. of N. The maximum gradient behind the station is therefore on a bearing of about 140°. The observed prevailing wind direction is 130° to 140°, which is in good agreement. The question arises as to the relative magnitudes of katabatic and Coriolis forces. The katabatic acceleration $a_k = g\alpha(\Delta T/T)$, where g is the acceleration due to gravity, α is the ice gradient, T is the potential temperature of the cold air and ΔT the difference in temperature between the cold (surface) air and the warm air above the inversion. Taking an average gradient over the 5 miles (8 km.) south of Mawson gives $\alpha \approx 1/25$. $\Delta T/T$ is rather uncertain but adopting 1/60 yields $a_k \approx 0{\cdot}66$. The Coriolis acceleration $a_c = 2wv \sin \phi$, where w is the angular velocity of the earth, ϕ the latitude 67·5°, and v is the wind velocity taken as 30 m.p.h. (a typical figure for Mawson), i.e. $v = 1{\cdot}3 \times 10^3$ cm./sec. Then $a_c = 0{\cdot}17$. For these conditions, the deviation β of wind direction due to Coriolis influence is given by $\sin \beta = a_c/a_k$, whence $\beta \approx 15°$. The fact that α is 1/10 rather than 1/25 within a mile of the coast will probably make β smaller right at the coast where the prevailing wind direction was recorded.[3]

A similar swing in sastrugi direction was noted by P. W. Crohn[4] during the journey from Mawson to the Stinear Nunataks, via Depot Peak, in 1956. The orientation changed from 150° to 170° over this route.

Inland, the major factor appears to be the influence of the Lambert Glacier. An indication of the pattern of the contour lines is obtained by joining altitudes measured on the 1957–58 traverse to identical altitudes recorded on the direct route to the Prince Charles Mountains. Even along the northern section of the traverse, between lat. 68° and 69° S., considerable drainage occurs from west to east, although the Amery Ice Shelf is 200 miles distant. The bearing of the maximum plateau gradient is shown in column 5 of Table 1. The figures are only approximate in the absence of detailed knowledge of contours to east and west of the traverse, but the general trend is unmistakable.

Between lats. 68° and 69° S. the plateau gradient is much smaller than along the coast, probably $\approx 1/120$. However, the fact that well-developed sastrugi existed here and further south, proves that a uniformly flowing katabatic wind is generated. Calculations of the relative values of a_k and a_c are complicated by the lack of information on $\Delta T/T$. Assuming typical inversions inland of 5° to 10° C., and taking the average wind velocity (based on daily readings of a cup anemometer) as 18 m.p.h., gives $\beta = 20°$ to 30°; this is at least the correct order of magnitude to account for the observed 'cross slope' flow (columns 5 and 6 of Table 1).

Still further south the form of the contours becomes largely speculative, as few other altitude measurements are available. As Fig. 2 shows, a ridge was

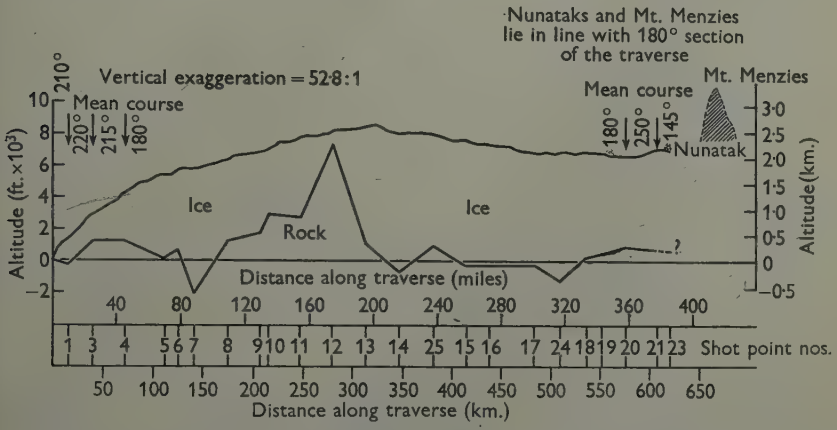

Fig. 2. Ice thickness profile. Mac-Robertson Land, 1957–58; seismic results only. Shot hole numbers do not correspond to camp numbers in all cases.

crossed at approximately 200 miles along the traverse, in lat. 70° 18′ S., after which the plateau altitude declines towards the south. There is certainly also a considerable fall to the east towards the Lambert Glacier which, according to radar altimeter measurements near the meridian 67·5° E., has an elevation of 2300 ft. (700 m.) in lat. 73° S., and 550 ft. (170 m.) in lat. 72° S. Fig. 3 is an attempt to sketch possible contours of the plateau west of the glacier, ignoring minor details. South of the ridge, a wind flowing downhill would appear to come from the north-west quadrant. No such phenomenon is observed, but several effects which appear in this region can probably be attributed to the influence of the ridge: (1) Sastrugi orientation swings abruptly from 187° at Camp 13, to 204° at Camp 15. (2) During the southern journey, sastrugi heights had been steadily increasing (column 7 of Table 1), the maximum of 54 in. (137 cm.) being recorded between Camps 12 and 13. Between Camps 13 to 15, however, a distance of only 21 miles (34 km.), a dramatic improvement occurred in the surface and the maximum sastrugi sighted fell to between 12 (30·5 cm.) and 18 in. (46 cm.); still further south, sastrugi height again increased. The ridge probably partly nullifies katabatic flow in its vicinity. (3) At the same time, snow dunes became less clearly defined in

direction, tending to merge into extensive soft snow patches. Tractors floundered worse in the snow here than at any other stage of the journey. Points (2) and (3) are interpreted as evidence of lighter winds in this region.

It is not known how far west of the traverse the Lambert Glacier continues to influence plateau contours, nor is anything known about plateau altitudes south of Camp 24, the termination of the 1957–58 traverse. However, east of the traverse, between lat. 71° and lat. 73° S., the average gradient towards

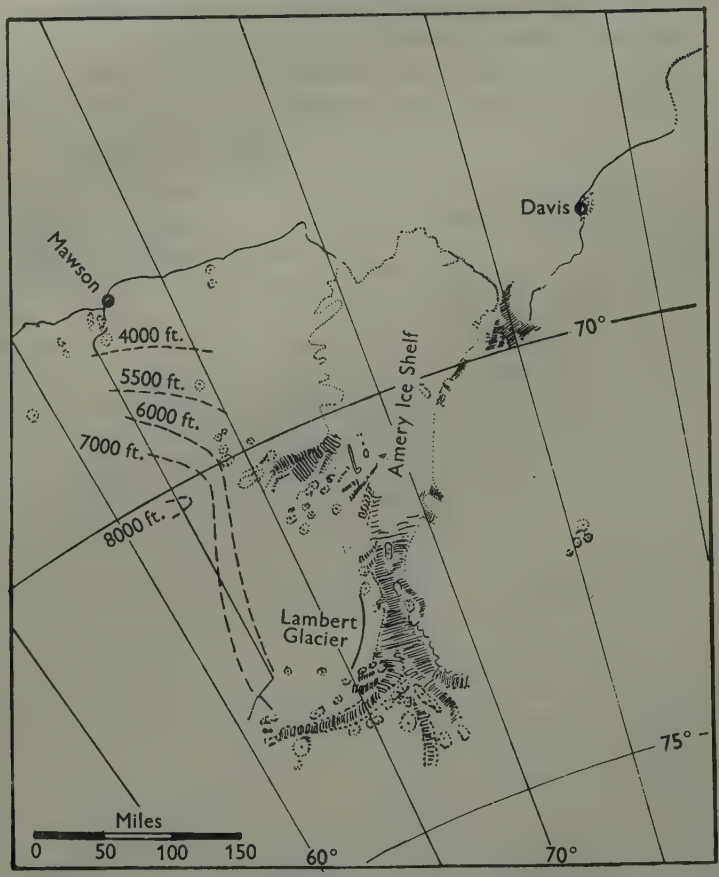

Fig. 3. Approximate ice surface form lines of the plateau south of Mawson, Mac-Robertson Land, 1957–58, indicating the extent of the depression associated with Lambert Glacier.

the main stream of the glacier is ~ 1/100, which is about the same as the normal plateau slope between, say, 40 and 140 miles (64 and 226 km.) from the coast. It is not surprising therefore that katabatic flow towards the glacier is quite strong, and also that sastrugi have a marked westerly component, 210° in lat. 71° S. and about 227° in lat. 72·5° S. The average wind speed recorded by the expedition during the thirty-nine days spent south of lat. 71° S. was 15·5 m.p.h. During the same period the average wind speed at Mawson was only a little greater, 16·9 m.p.h. Incidentally, very strong and continuous

winds have been noted in lat. 70° 50′ S., long. 68° 14′ E., which was frequently visited during the year because an aviation fuel depot had been established there.

While it is not possible at this stage to present a detailed analysis of the katabatic wind pattern, the gross features observed south of Mawson appear to be understandable, at least semi-quantitatively, in terms of the topography. The Lambert Glacier plays a major role in the surface winds of this region. It is responsible for a low-lying zone, extending over at least 100,000 sq. miles (259,000 sq. km.), which serves as a 'sink' into which drain katabatic winds, certainly from west and south and presumably also from the east. The 1957–58 traverse lay wholly within this 'sink', which accounts for the fairly strong wind (comparable with that at Mawson during the same period) encountered along most of the route. Normally one would not expect strong katabatic flow so far south of the coast. Apparently there is a gradual transition from coastal katabatic flow (S.E. wind) to local flow into the Lambert Glacier depression (S.W. wind), the whole effect being clearly registered in the sastrugi pattern.

Further information is required on sastrugi orientations east of the glacier, data which can be secured very satisfactorily by air photography. Similar information from south of the glacier, and also to the west of the 1957–58 traverse, would be valuable in delineating the true extent of the drainage region. Employed in this way, sastrugi can be convenient "indicators" of surface topography.

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THE OPERATION OF A SURVEY MOTOR BOAT IN ANTARCTIC WATERS, 1956–58

By lieut. c. j. c. wynne-edwards, r.n.

[*MS. received 5 February 1959.*]

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Introduction

During the Antarctic summer seasons of 1956–57 and 1957–58, a British Royal Naval Hydrographic Survey Unit operated off the coast of west Graham Land. Working sometimes from stations of the Falkland Islands Dependencies Survey, and sometimes from camp sites, an area of coastline from Port Lockroy southwards to Ferin Head was systematically examined, triangulated and charted.

The mobility of this small unit depended on one all-important factor, the constant availability of a specially converted 29 ft. motor boat, which acted as both transport and home.

General specification and layout

The boat was a specially modified version of the latest type of survey motor boat used by the survey ships of the Royal Navy. Specifications were: length 29 ft., beam 8 ft., draught 2 ft., displacement 5·75 tons (fully loaded), powered by a Perkins P4M Marine diesel engine developing 58 s.h.p. at 2000 r.p.m.

The boat was divided into three compartments, each separated by a watertight bulkhead. Two further watertight bulkheads existed between the forward compartment and the bows, and between the after compartment and the stern.

The forward compartment carried general stores, food, surveying equipment, spare gear, and a small galley. There was also sleeping space for two people.

Amidships, the engine-room compartment was completely self-contained, although windows gave access to the compartments forwards and aft of it. Fuel tanks, giving 30 hours steaming at full speed, lay on either side of the engine; and there was also room to carry further fuel stowed in cans around the engine room.

The after compartment was the operating centre of the boat and housed the echo sounding set, chart table for survey plotting, and the radio. Doors at the after-end gave direct access to the steering and surveying position at the stern. Four people could sleep in the after compartment.

Modifications for use in ice

Hull. As an initial protection against ice damage, copper sheathing was aid over the double-diagonal mahogany strakes which formed the hull. This sheathing extended from the keel upwards to one foot above the waterline ver the whole boat's length. An "armoured-belt" of 1 in. greenheart wood vas overlaid to protect the waterline. This belt extended from just above the ilge-keel to 6 in. above the waterline, over the whole boat's length. A final overing of copper was laid over this greenheart belt.

Power unit. An electrical starter, assisted by a "Ki-Gas" injection unit, ssured instant starting in the coldest weather. No starting failures were ecorded.

A closed-circuit water-cooling system with protected pipes running under he hull of the boat close to the keel, working on the heat-exchange system, roved adequate. The system was filled with a 50/50 mixture of ethyl glycol nd water.

Steering and control gear

A special control arrangement known as "Kitchen" gear was incorporated or steering and manoeuvring the boat. In place of a normal rudder, special wivelling cups, or buckets, were fitted to either side of the single propeller. These could be opened or closed to control the flow of water around the pro-eller, and thus regulate the speed of the boat itself. When fully open they acted s rudders on either side of the propeller, and the boat could be steered by their novement in the normal manner, to port or starboard. When fully closed, e. with both cups right aft and adjacent to each other, the boat would start o move astern, although the direction and speed of the propeller remained nchanged.

The "Kitchen" gear was controlled by the coxswain steering from the stern; he cups being opened and closed by a small wheel mounted directly beneath he tiller. Some practice was needed to perfect operation, but thereafter here was a marked increase in manoeuvrability over more conventional types f control.

Operation in ice

With the boat control at the stern, it was necessary to have a second person recting the helmsman when manoeuvring in heavy ice. The pilot usually ood on top of the engine room, or forward compartment roof, thus giving mself maximum height and visibility for spotting leads. Facing forward he rected the helmsman by a system of hand signals. If the brash ice was rticularly troublesome, one or two people in the bows of the boat armed ith boat-hooks helped to keep the path clear.

For general direction the helmsman had a magnetic compass with his ordered urse marked by a moveable cursor, and could tell at a glance how far he was f track during ice manoeuvring.

The echo sounder was operated when moving in new areas, and often ovided the only warning of small snow-covered rocks which merged with

the pack-ice. Except when a piece of ice passed under the boat and obscured the trace, the echo sounder was not affected by manoeuvring in ice. In clear water remarkable results were often achieved, due possibly to the low salinity of the sea water. It was not unusual to record depths of 500 fathoms or over on an echo-sounder set designed to reach 120 fathoms. During the Antarctic summer season 1957–58 unusually bad ice conditions were met with south of the Argentine Islands. For several weeks the boat was operating in broken pack ice varying from three-tenths to nine-tenths in coverage, and up to 8 ft. in thickness.

Provided the pack ice was broken and there was no pressure, it was always possible to maintain slow speed, manoeuvring in the leads, and gently buffeting a way through. The "Kitchen" control gear was invaluable in this connexion as the boat could be turned on its own axis through a whole circle. The cups around the propeller seemed to act as guards against large bits of ice; the only damage caused being by small hard bits of ice which occasionally found their way between the cups and the propeller itself. These were quickly cleared by reversing the propeller direction. The propeller was changed three times and the main shaft once; considerable torsion strain is unavoidable on the latter when navigating in ice.

Towards the end of the 1958 season, new sea ice started to form, but this proved no trouble to the boat, which negotiated new ice 4 to 5 in. thick without trouble.

No serious hull damage was suffered during three months continuous operations in ice. The outer copper-sheathing tended to strip where the fastenings were continually rubbed and broken off by ice, but these were easily mended.

Apart from ice damage already mentioned, engine work was nearly all restricted to routine maintenance. Some trouble was experienced with the water-pump, but this unit was refitted from spares carried. Great stress was laid on regular routine maintenance and machine checks.

Conclusion

The motor boat returned from the Antarctic in June 1958, aboard R.R.S. *John Biscoe*, having steamed 5300 nautical miles independently in Antarctic waters in two seasons. This included a voyage from the Argentine Islands southwards to Lallemand Fjord, and back, a distance of 250 miles.

Between January and April 1958, the west Graham Land coast, from Lemaire Channel in the north to Ferin Head in the south, had been surveyed cartographically and geologically. Most of the off-shore islands in the area had also been examined.

The maximum passenger load during this time was twelve people; on the average the boat carried seven people and about 600 lb. of survey equipment and stores.

The advantages of a good well-found launch on a coast such as west Graham Land can easily be assessed. With a largely inaccessible hinterland, the

Survey motor boat off Cape Pérez, March 1958

During the survey of Grandidier Channel a number of safe small-boat anchorages were discovered and used

Operations of a survey motor boat in Antarctic waters, 1956–58

Photographs by F. E. Wooden

(*Facing p.* 448)

exploration of the coastline and off-lying islands had previously been largely restricted to sledging parties on sea ice during the period when this is well formed. The limitations in weight, range and endurance of a sledge party compared with a motor boat are obvious.

The dangers of ice and weather should never be underestimated, however, and the exercise of seamanlike judgement must remain the primary consideration in any Antarctic boating operation.

FIELD WORK

UNITED STATES HYDROGRAPHIC SURVEYS IN CANADIAN WESTERN ARCTIC, 1955–57

[Summarized from Hydrographic survey in the Arctic, by Commander T. K. Treadwell, U.S.N., in the *Military Engineer*, March–April 1958. An account of the operations in 1957 was published in the *Polar Record*, Vol. 9, No. 59, 1958, p. 147–48.]

The building of the Distant Early Warning Line (D.E.W. Line), following the 70th parallel across north America, necessitated the transport of enormous quantities of building materials, stores and equipment along sea routes in which no proper hydrographic surveys had been made. Ships of the Hudson's Bay Company, and other concerns, had carried goods between Arctic settlements for many years, but these were quite inadequate to cope with D.E.W. Line requirements, and the rudimentary charts they used were of no use to the vessels of the size that would be required for the project. In 1954 the United States Navy Hydrographic Office undertook to chart some 1000 miles of the coast of the Canadian Arctic, beginning at the Alaska border. The survey programme was phased over three of the short navigating seasons of the Arctic summer. During the first season, survey ships were to reconnoitre ahead of the transports, locating and exploring dangerous stretches. In the complete absence of port facilities all cargo had to be unloaded by means of small boats, so the beaches and approaches of each radar station site had to be surveyed. During the second season, a survey party were to be flown early in the season to establish triangulation nets in areas where reconnaissance had shown the need for detailed survey. As soon as the ice permitted, the survey ships would return to continue soundings. The programme would continue and be completed during the third season. Throughout the operations navigational aids were to be built, oceanographical observations taken and, when opportunities arose, reconnaissance surveys were to be conducted towards the north and east to investigate the possibility of a deep-draught passage through to the Atlantic Ocean. As most of the surveys had to be made immediately ahead of transport ships, speedy processing and dissemination of results was imperative. All field surveys were plotted on master sheets and kept up to date, so that working copies could be distributed quickly. Radio reports were sent regularly giving safe tracks to follow and general navigational information.

Operations in 1955

The survey ship used was U.S.S. *Requisite*, a converted minesweeper partially strengthened for use in ice. She was accompanied by U.S.C.G.C. *Storis*, an Arctic buoy tender, specially designed to work in ice and equipped with a survey echo sounder, short range sonar and a flight deck to accommodate two H.T.L. Bell helicopters. A naval hydrographic officer and two civilian hydrographers were carried. The ships attempted to reach the area early in the summer, well before the transports, but ice prevented their reaching Amundsen Gulf until 1 August. Conditions then improved and they experienced no difficulties working from site to site as far as the eastern end of Coronation Gulf. The ships generally worked in line abreast, about half a mile apart, thus providing two parallel line of soundings. Ships' boats, with portable echo-sounders, scouted ahead to give advance warning of sudden shoals, and the helicopters provided general ice information. At each radar station site a track was sounded in from the main route to the beach. From the Mackenzie River eastwards there is mostly deep safe water, but extensive

shoaling was encountered in Dolphin and Union Strait. There are a number of islands in the strait and the discovery and buoying of a channel through them was a long and tedious operation. The water through Coronation Gulf and Dease Strait is deep and clear. Queen Maud Gulf, however, presents formidable difficulties of ice and shoals. The gulf contains thousands of low-lying gravel islands providing poor radar targets. Interspersed among these islands are submerged banks and ridges often rising to within a few feet of the surface. After prolonged reconnaissance a tansit was made through the south-eastern part of the gulf to Simpson Strait, the route formerly used by the Canadian R.C.M.P. patrol vessel *St Roch*. Simpson Strait was free of ice but otherwise as full of difficulties as Queen Maud Gulf. The clear waters of Shepherd Bay were doubly welcome, being also the end of the season's programme. On the return journey a better route through Queen Maud Gulf was discovered, and possible winter anchorages surveyed at Booth Island and Hershel Island.

In addition to off-shore surveys, two six-men teams were flown to the area to conduct surveys of beaches, anchorages and approaches. They consisted of naval and civilian hydrographers and under-water demolition units. Surveys of the D.E.W. Line stations began in mid-June with the establishment of control points and triangulation. The teams worked from site to site selecting landing beaches, determining beach profiles and setting range markers for anchoring and beaching operations.

Operations in 1956

On the results of the 1955 surveys it was decided to concentrate on work in Dolphin and Union Strait, Queen Maud Gulf and Simpson Strait, with minor excursions to Cambridge Bay, Cape Parry and Cape Bexley.

The advance survey party was flown into the area late in May 1956 to set up a control network for these operations, and remained there until mid-September. It consisted of two naval and six civilian hydrographers and one from the Canadian Hydrographic Office. Transport in the area was entirely by two Navy H04S Sikorski helicopters, the party moving camp as the triangulation was carried forward. Special techniques to speed up the work were adopted, including leap-frogging of reconnaissance and construction parties with observing parties, the use of light, prefabricated survey signals and of iron rods in place of concrete monuments. At each radar site connexions were made to the construction contractor's land-survey traverse and ties to previous hydrographic local traverse or triangulation nets. The triangulation of Dolphin and Union Strait was completed, using 27 stations. The triangulation between Cambridge Bay and Simpson Strait was completed using 102 stations.

Most of this work had been finished by the time *Requisite* and *Storis* were able to reach the area, and field sheets were supplied to them. The two ships carried out limited surveys off Cape Parry and Cape Bexley and established a safe passage down the eastern side of Dolphin and Union Strait. They also surveyed the shoal areas of Queen Maud Gulf and Simpson Strait. U.S.C.G.C. *Sedge* and *Citrus*, small buoy tenders, worked in Simpson Strait and in the approaches to Cambridge Bay.

Operations in 1957

The only work that remained to be completed in 1957 was an extension of surveys in Queen Maud Gulf, the search for a deeper passage through Simpson Strait, and reconnaissance of a deep-water passage through to the Atlantic Ocean. Survey parties were carried in *Storis* and in two other buoy tenders, U.S.C.G.C. *Spar* and *Bramble*. Ice conditions were extremely difficult east of Dolphin and Union Strait

but the programme was fully carried out. The ships charted a route up Ross Strait and were met at the eastern end of Bellot Strait by the Canadian icebreaker *Labrador*. She conducted them down the deep-water passage through the strait which she had been charting during the season, and out into the safe waters of Prince Regent Inlet and Lancaster Sound.

Summary

As a result of these operations 1000 miles of a deep-water North West Passage were charted. In addition, five hundred square miles of detailed hydrographic survey were made in the most dangerous areas. About 285 miles of coastline were covered by triangulation and 28 radar reflector towers were built as navigational aids. The results of the surveys were published in a series of 33 charts and in greatly improved sailing directions.

EXCHANGE OF VISITS BETWEEN CANADIAN ESKIMOS AND GREENLANDERS, 1956 AND 1958

[Summarized from the *Arctic Circular*, Vol. 9, No. 1, 1956, and *Northern Affairs Bulletin*, Vol. 5, No. 4, 1958.]

During August 1956 a party of five Greenlanders paid a visit to the eastern Canadian Arctic to see the traditional mode of life of the Canadian Eskimo. The party consisted of P. Nielsen, a member of the Greenland Landsraad; F. Nielsen and R. Petersen, teachers; K. Hertling, lawyer and interpreter, and U. Kristiansen of the Greenland radio system. They were met at Angnakadlak by M. L. Manning, Department of Northern Affairs, and an Eskimo pilot. Visits were paid to Pangnirtung and Frobisher Bay, a week being spent at each settlement, and the party arrived back in Godthaab on 6 September.

A return visit was paid in September 1958 by five administrative officials from the Arctic Division, Northern Affair's Department, and ten Canadian Eskimos. The Eskimos were leaders from settlements representative of all parts of the Canadian Arctic: Aklavik, Cambridge Bay, Cape Dorset, Fort Chimo, Spence Bay and one from the Arctic Division, Northern Affairs Department, Ottawa. The party travelled in C.G.S. *Ernest Laponte* and visited centres on the west coast of Greenland from Julianehaab to some 300 miles north of the Arctic Circle. The visitors were greatly impressed by the development of social services and commerce in Greenland.

DANISH SCIENTIFIC WORK IN GREENLAND, 1957

[Summarized from information supplied by Arktisk Institut, København.]

West Greenland

Biology. Ulrik Röen completed his limnological investigation of the fresh-water lakes of Diskofjord district, and left the station at the end of the 1957 season. He will continue his investigations at the university of København in the fresh-water biological laboratory at Hillerød. His appointment as scientific leader of the Universitetets Arktiske Station, Godhavn, ended on 1 April 1958, and Höpner Petersen has replaced him. He is to work on the marine biology of the Disko Bugt area, measuring plankton production by means of Stemann Nielsen's C_{14} method.

Geology. Parties from Grønlands Geologiske Undersøgelse [Geological Survey of Greenland] worked in four regions in west Greenland during the summer of 1957:

(1) S. Floris and K. S. Jørgensen worked in the Nugssuaq area. (2) A. Berthelsen spent a short time revising the map of the west part of Tovqussaq in the Sukkertoppen district. (3) In the Ivigtut and Nunarssuit area twenty-five geologists, under the direction of A. Berthelsen and divided into twelve parties based on Ivigtut, continued the survey begun in 1956. The groups worked as follows: A. Berthelsen continued the survey in the Ivigtut peninsula and made a reconnaissance from Sermiligarssuk to Smallesund and in Kobberminebugten. C. H. Emlius (Durham) completed work on the Ika Grønnedal massif, worked on the survey of K2-granite and visited the Qujartofik and Storø-granite. N. Henrikson surveyed the area west of Norlandet. B. Upton (Oxford) completed the survey of the Kunait massif. C. Froidevaux and J. Muller (both from Neuchâtel) surveyed the island of Arsuk and the skerries west of it. E. Bondelsen surveyed the island of Tonarssuk. F. L. Jakobsen surveyed the western half of the peninsula between Sermiligarssuk and Tigssaluk, while L. Bounard (Lausanne) surveyed the central part of the peninsula and M. Burri (Lausanne) the eastern part and inland towards the inner part of Arsukfjorden. S. B. Jensen surveyed Kangarssuk, Qujartorfik and Tavdloruit. W. T. Harry (St Andrews) surveyed Alangorassuaq and T. C. R. Pulvertaft the area around Nunarssuit. (4) Finally, in the Julianehåb area, a party of twelve under J. Bondam carried out tachymetrical and radiometrical measurements on Kvanefjældet in addition to geological survey. E. Hamilton and S. Moorbath surveyed the central part of the Ilimaussak-batholite, and Moorbath alone the south-western marginal areas. The eastern part of Tugtugtoq was surveyed by Upton assisted by Hansen and Moorbath. J. Sorensen and Else Breval carried out survey and petrographical work at Igdlunguak, in Skovfjorden and at Qeqertarssuaq in Kangerdluarssuk.

All geological groups were equipped with Geiger-Müller counters. Samples for absolute dating were collected by all groups. In September J. Bondam carried out a radiometric and tachymetric survey of an area known as "Jernhatten" in Grønnedal.

Geochemical investigations. E. Hamilton carried out a series of preliminary field investigations elucidating the uranium-geochemistry with special reference to the distribution of uranium in lake and river water.

Glacial geology. A. Weidick continued his study of the marginal zone of the ice sheet and movements of glaciers in south Greenland. He concentrated his work in the area of Nordre Sermilik and around Tunugdliarfikfjorden.

Survey. Ground measurements to assist in making photo-grammetric maps at a scale of 1:50,000 were made in the area between Nanortalik, Frederiksdal and the island group of Kitsigsut, and at the head of Sermilikfjorden and Skovfjorden (Narssaq). Work was also carried out in the area between Søndre Strømfjord and Disko Bugt and around Færingerhavn by sixteen men.

Archaeology and ethnology. Investigation of a site near Godhavn was continued by G. Nellemann and Professor H. Tegengren (Finland). Another site in Disko Fjord contained both Dorset and Sarqaq cultures in stratigraphically undisturbed layers.

Ethnological investigations were carried out on Disko, Kronprinsens Ejland and further north in Umanaq and Upernavik.

Excavations, begun in 1955, were continued in the area around Sermermiut, Jakobshavn, under B. Fredskild. The main objects were the collection of pollen, seed and twigs, and the study of the most widely distributed plant community types. Some work was also carried out near Godhavn, at Orpigsoq, and at Christianshåb.

Glaciology. Glaciological investigations, under the direction of Børge Fristrup, in connexion with the I.G.Y., were carried out in three centres, from June to October 1958.

The first party, under the leadership of Jens Fabricius, worked on a glacier near Kitdlavat on Sermerssoq Øen. Other members were K. Jørgensen, H. Rassussen, K. Bek and T. Hatting.

The second party, led by J. T. Møller, worked on Sermikavsak on Upernavik Øen. Members were F. Floto, M. D. Mikkelsen and H. Kuhlmann, who made a special study of glacier winds and air temperature up to 15 m. above the ice level.

The third party was led by B. Fristrup himself and worked on Hurlbut Gletscher in Thule district. Other members were M. Holland, H. V. Larsen and C. Velsbo. During a snow storm in July, Holland and Velsbo lost their lives on a trip between the camp on the glacier and the base camp on the coast.

A full programme of glaciological investigations were carried out at all three stations.

East Greenland

Geology. Two geological parties, under the direction of Lauge Koch, were flown to Mesters Vig in April and carried out survey on both sides of Schucherts Flod Between mid-July and September two parties worked in the Scoresby Sund and Ella Ø districts. The geological mapping between lats. 72° and 76° N. has now been completed and the fifteen map sheets are ready for press. This represents the area approximately between Mesters Vig and Bessels Fjord.

Geophysics. Temperature measurements at considerable depths were made in the lead mine at Mesters Vig, with a view to determining the geothermal gradient.

Zoology. Christian Vibe carried out an investigation in the area between Kap Farvel and Nunarssuit into the damage done to sheep by the White-tailed Eagle (*Haliaeetus albicilla*). He discovered that, although they are responsible for some damage, the Raven does considerably more. The total number of White-tailed Eagles breeding in east Greenland is estimated at 50 pairs.

Ice floe marking. F. Hermann carried out a series of experiments in the marking of ice floes from the air as a means of studying drifting ice. He took part in six ice-reconnaissance flights north of Mesters Vig organized by Den Kgl. grønlandske Handel (Royal Greenland Trading Company) and A/S Nordisk Mineselskab, dropping strips of coloured plastic foil from the aircraft. Subsequent flights, however, showed that the markers could only be seen in very rare instances and the method had no practical application.

CANADIAN DEPARTMENT OF MINES AND TECHNICAL SURVEYS, EXPEDITION TO MELVILLE PENINSULA, 1957

[Summarized from an account in the *Arctic Circular*, Vol. 11, No. 2, p. 27–29, 1958.]

V. W. Sim and D. Bissett, of the Geographical Branch of the Canadian Department of Mines and Technical Surveys, spent from mid-May to early September 1957 on a reconnaissance study of the geomorphology and human geography of the northern part of Melville Peninsula.

They were flown from Churchill to near Hall Beach, on the east coast of the peninsula, on 19 May and there set up a base for the season. The aircraft, before returning south, established a food cache for use later in the season at the north end of Hall Lake and at three other points, but in the event only the first was used.

From 25 to 28 May they made a sledge trip to the west end of Hall Lake to leave food and a canoe for use later in the summer.

Between 31 May and 13 June they sledged to Igloolik and Fury and Hecla Strait

then, by way of Quilliam Bay, to Amherst Island. There ice conditions prevented further travel westwards, and after working on Amherst Island and the adjacent mainland coast, they returned down Griffiths Bay, along a system of fracture valleys in the Precambrian terrain, to Richards Bay. They visited Northeast Cape and Bouverie Island before reaching Igloolik on 8 June and Hall Beach on the 13th.

Another sledge trip was made from 15 to 20 June to Parry Bay where a supply of fuel was left at the west end of the bay, and the country west of Amitioke Peninsula was reconnoitred. The return journey was made by way of South Ooglit Island. By this time travelling conditions had deteriorated owing to melt water on the sea ice, but most of the north-east coast of the peninsula had been reconnoitred and all the Eskimo camps there visited.

On 26 June the party was flown to Garry Bay, on the west coast of the peninsula, where they carried out geomorphological studies until flown back on 3 July.

On 8 July they left on foot to visit the interior of the peninsula, reaching the food and canoe left at the north end of Hall Lake on the 10th. Ten days were spent making geomorphological studies along a contact zone between Palaeozoic sediments of the eastern lowlands and Precambrian crystallines of the interior. They reached Hall Beach again on 19 July after covering a distance of about 175 miles.

They were flown to Sarcpa Lake, in the middle of the peninsula, on 25 July and made a number of one-day traverses from there. An attempt to canoe around the shores of Hall Lake was foiled by ice and the journey had to be continued on foot. Returning to Sarcpa Lake on 3 August they were flown back to Hall Beach on the 5th.

The sea ice had now cleared from Foxe Basin and enabled the party to travel up the east coast in a 16 ft. aluminium boat. They left for Parry Bay on 12 August, hoping to reach Hall Lake by way of the Ikerasak River, but stormy weather held them up. They spent a week working in the valleys of the larger streams entering Parry Bay, and on Amitioke Peninsula, returning to base on the 21st.

A final trip was made to Igloolik between 25 and 30 August, and the two men were flown out to Frobisher on 4 September.

CANADIAN OPERATION "HAZEN", 1957–58[1]

[By G. Hattersley-Smith.][2]

Operation "Hazen" was organized by the Defence Research Board, as part of the Canadian International Geophysical Year programme, to carry out meteorological, glaciological, geophysical and geological investigations in the Lake Hazen region of northern Ellesmere Island during two summers and one winter. Biological and archaeological studies were also made in 1958. The establishment of the base camp on Lake Hazen and the work of the first summer have already been briefly reported.[3] The following Canadian government organizations participated in the operation during the 1958 summer: Fisheries Research Board, Geographical Branch Geological Survey, National Museum and Wildlife Service.

The winter party, consisting of four graduate students from McGill University, relieved the first summer party on 18 August 1957, and remained throughout the following summer. They were: C. R. Harington, in charge, geographer; C. I. Jackson, meteorologist; J. M. Powell, botanist; and D. I. Smith, geomorphologist.

[1] Published by permission of the Chairman, Defence Research Board of Canada.
[2] Geophysics Section, Defence Research Board.
[3] *Polar Record*, Vol. 9, No. 58, 1958, p. 26–27. *Operation "Hazen": Narrative and Preliminary Reports for the 1957 Season.* Ottawa, Defence Research Board, 1958, 57 p., illus., maps.

The 1958 summer party comprised, in addition to the above, the following:

G. Hattersley-Smith, Leader, Glaciologist
Lt.-Cdr. J. P. Croal, R.C.N. Co-ordinator for air and sea operations
Professor R. E. Deane, Deputy leader, Pleistocene geologist
K. C. Arnold, Surveyor
M. Brochu, Geographer
R. L. Christie, Geologist
F. S. Grant, Geophysicist (gravity)
J. R. Lotz, Meteorologist
M. S. Maxwell, Archaeologist
I. A. McLaren, Aquatic biologist
R. B. Sagar, Assistant glaciologist and meteorologist
H. Sandstrom, Assistant geophysicist
Professor J. H. Soper, Botanist
J. S. Tener, Mammalogist
B. P. Walker, Assistant geologist
J. R. Weber, Geophysicist

During period of airlift only:

Sgt. D. Engel, R.C.E., Mechanic
Sgt. J. E. Robertson, R.C.S., Radio mechanic

The crew of the DC-3 ("Dakota") aircraft of 121 Communication and Rescue Flight, Air Defence Command, R.C.A.F., attached to the operation was as follows:

F/Lt. M. W. Utas, Captain
F/Lt. D. B. Dragon, Navigator
F/O P. J. Ferrigan, Radio officer
F/O E. L. Harris, Co-pilot
P/O L. L. Legear, Navigator
Cpl. A. D. Chalkley, Flight-engineer
L.A.C. R. C. Evans-Davies, Electrical engineer
L.A.C. A. K. Mann, Aeroengine technician

The winter party successfully achieved their main objective, a complete record of synoptic meteorological observations. Studies were also made in micro-meteorology, on ice growth and snow cover on the lake, ground temperatures and local wildlife. The same party maintained meteorological observations throughout the summer to complete a year's record—the first of its kind from an inland station north of the Canadian Arctic mainland. The living hut was an "Attwell" shelter, heated by an oil-burning stove, which was also used for cooking; a second "Attwell" shelter was used for stores.

On 29 March 1958 a C.130A ("Hercules") aircraft of the United States Air Force, under the command of Major C. E. Fitzwater, U.S.A.F., landed on the lake from Thule Air Base with a load of 9 tons of fuel and the first visitors to the station since the previous August. Supplies for the summer and fourteen members of the summer party arrived with the main airlift, which started on 28 April and was staged through Churchill, Resolute and Thule Air Base. The airlift, under the direction of the Air Officer Commanding, Air Transport Command, R.C.A.F. (A/C F. S. Carpenter), was carried out by a C.119 ("Flying Boxcar") aircraft of 436 Squadron, with Sqn.Ldr. R. V. Smith, in charge, and F/Lt. H. Berk, captain of the aircraft, and by the above-mentioned DC-3 aircraft of 121 C. and R. Flight, which provided the airlift from the base camp to the field stations. The first landing was made on 30 April on an unprepared strip on the lake ice; subsequent landings were made on an airstrip cleared to a length of 5000 ft. by a bulldozer, taken to the lake the previous spring. A total of six landings were made by the C.119 aircraft in transporting the personnel, three dog teams and 30 tons of fuel, stores and equipment, the last on 14 May.

On 30 April the Gilman Glacier station, occupied the previous summer, was reopened by the "Dakota". During the next few days a large cache of food and equipment was dug out, and the seismic and meteorological equipment, stored in pyramid tents for the winter, was overhauled. In May, fourteen further flights were made to the glacier with stores and equipment, and in order to transport field parties to the ice cap near Mount Oxford, to Markham Inlet and to a glacier at the head of Tanquary Fiord. Landings were also made at Alert, Ward Hunt Island, Fort Conger and Judge Daly Promontory. On 29 May the "Dakota" left Lake Hazen to return to its base near Vancouver. Two days later a C.119 aircraft of 436 Squadron landed

with the remaining four members of the summer party. On 10 June a "North Star" aircraft arrived with the Chairman of the Defence Research Board, Dr A. H. Zimmerman, and a party of sixteen senior Canadian and United States service officers and government officials for a visit of two days.

Thirteen members of the expedition were based on the lake during the summer. Gravity stations were established at Lake Hazen, Ward Hunt Island, Markham Inlet, Gilman Glacier, and Fort Conger, which were tied in with the Canadian and Greenland network by observations at Resolute, Dundas (Greenland) and Alert. The geological reconnaissance, started in 1957, was extended across the ice cap to Markham Inlet, across the plateau area to Alert, eastward to Fort Conger and southward to Judge Daly Promontory. Detailed surveys of Pleistocene geology and geomorphology were carried on in the vicinity of the lake, and studies of temperature, depth, sedimentation and bottom cores were made over a wide area in the lake itself. Echo sounding traverses by boat during the second week of August covered much of the central section of the lake; a concentration of four-tenths ice in the western part of the lake impeded sounding in that area. The aquatic life of the lake was studied, with special reference to the feeding habits and life cycle of the Arctic Char, which abounds there; measurements on over 500 of these fish were recorded. About 100 species of flowering plants were found in the immediate vicinity of Lake Hazen; two full collections were made, and many of the species were photographed in colour. A study was also made of the vegetation of certain nunataks at an elevation of 3000 to 4000 ft. (915 to 1220 m.) where some thirty species of flowering plants are represented. A reconnaissance of the wildlife of the area was made, and detailed work was carried out on the Musk-ox and its life history. Measurements were made on some 240 old Musk-ox skulls, and teeth were collected for ageing by counting of growth rings. Specimens of birds and mammals were collected for the National Museum. Archaeological sites on Chandler Fiord, Conybeare Bay, at the east end of Lake Hazen, at the mouth of the river flowing from Gilman Glacier, and at the head of Ruggles River were excavated. The latter site had been partially excavated by Greely during his summer journey from Fort Conger in 1882; his record left in a cairn near Henrietta Nesmith Glacier during his spring journey the same year was recovered in 1957. The sites range in age from possibly as early as the 10th or 11th century to the time of Peary's Eskimos. A number of sites were recorded, but not excavated, in the foothills up to 15 miles north of Lake Hazen. A large number of artifacts were collected for the National Museum.

Six members of the expedition were based on Gilman Glacier throughout the summer. During May, seismic work was carried out on Gilman Glacier and in the vicinity of Mount Oxford to extend the 1957 coverage, and in June a gravity traverse, in conjunction with a level survey, was carried from sea level in Markham Inlet to the Gilman Glacier camp. In July gravity determinations were made on the ice along a number of transverse profiles of Gilman Glacier and over a wide area east and south of Mount Oxford, where seismic depth control had been established. At the end of the season the gravity traverse was extended from Gilman Glacier to the geodetic station on Johns Island along the line of the level survey made in 1957. The gravity and survey traverses were then extended to sea level at the mouth of Ruggles River. In this way gravity stations at 1 km. intervals, with accurate topographic control, were occupied across the United States Range from the Arctic Ocean to Chandler Fiord.

Glaciological studies at various locations up to 6500 ft. (1980 m.) provided data on annual accumulation for the last 30 years. At the Gilman Glacier camp a hole was cored to a depth of 25 m.; a detailed study of crystal structure and density in the recovered core was made, and temperatures at various depths in the hole were measured throughout the season with thermistors. Measurements of accumulation

and ablation on the glaciers and ice cap were made over a wide area extending from Tanquary Fiord in the west to Markham Inlet in the north-east, and northwards to the upper reaches of the glaciers above M'Clintock Fiord and Disraeli Fiord on the north coast. Reconnaissance geological work was carried out in the areas visited. Observations on a network of about 30 stakes, many of which were set up in 1957, provided data on the movement of Gilman Glacier over one year. Studies were also made of marginal, surface and tectonic features of this glacier. A full-scale meteorological and micro-meteorological programme was carried on at the Gilman Glacier camp. The micro-meteorological work, in addition to measurements of temperature and wind speed at four levels close to the surface of the glacier, also included measurements of incoming and outgoing radiation, not made in 1957.

Travel in the vicinity of the lake was by tractor, dog team, pack dog and motor boat. Two "Eliason" motor toboggans[1] and two dog teams were used on the glaciers and ice cap throughout the summer. Dogs were hired from Thule (Kanaq) by courtesy of the Danish authorities. During the first two weeks of August the operation was greatly assisted by Dr Terris Moore, who in his Piper "Super-Cub" aircraft, equipped with floats, flew members of the party on a number of reconnaissance flights, and proved the extreme versatility of this aircraft, which he had flown up solo from the United States.[2]

The icebreaker U.S.S. *Atka*, Cdr. W. H. Reinhardt, U.S.N., arrived from Thule Air Base at the head of Chandler Fiord on 9 August, and evacuation by helicopter of the party, dog teams, scientific equipment and specimens started. At the same time a number of survey flights by helicopter were made. The evacuation of the expedition, except for five members who remained for scientific reasons, was completed by 14 August, when *Atka* sailed for Thule. The remaining members of the party were flown out on 20 August by a "Canso" flying boat of 121 C. and R. Flight, under the command of F/lt. E. M. Neil, R.C.A.F.

A limited programme of field work is planned for the summer of 1959.

GEOLOGICAL INVESTIGATIONS IN THE PARRY ISLANDS, 1958

[Note provided by R. Thorsteinsson and E. T. Tozer and published by permission of the Director, Geological Survey of Canada, Department of Mines and Technical Surveys, Ottawa, Canada.]

During the summer of 1958, a field party of the Geological Survey of Canada carried out a reconnaissance survey in the Parry Islands using a Piper Super-Cub PA 18A aircraft. This was the first time that a fixed wing aircraft, equipped with wheels designed for landing on unprepared terrain, had been used for geological mapping in Canada. The party consisted of two geologists. R. Thorsteinsson and E. T. Tozer, jointly in charge, and W. W. Phipps, a licensed pilot-engineer. The aircraft was provided under contract by Bradley Air Services, Ontario, of which Phipps is Vice-President.

The main base was at Tingmisut Lake, at the south end of Sabine Peninsula,

[1] *Polar Record*, Vol. 9, No. 60, 1958, p. 267–68. [2] See p. 417–20.

North shore of Lake Hazen and Johns Island showing tracks leading from air-strip (A) to "Shoran" station (S), and camp (B)

Canadian Operation "Hazen", Ellesmere Island, 1957–58

Photograph by Royal Canadian Air Force

Aircraft beside Parry's Rock in Winter Harbour, South Melville Island, August 1958. The inscription describing Parry's wintering in the harbour, 1819–20, is on the rock face to the right of the aircraft's wing. The weather vane was erected by Capt. J. E. Bernier, who wintered there, 1908–09

Camp at Leffingwell Crags Mountain, Mackenzie King Island, July 1958, showing southernmost of the three sandstone masses that form the crags

Geological Survey of Canada. Survey by Piper Super-Cub aircraft in the Parry Islands, 1958

Photographs by Geological Survey of Canada

(*Facing p.* 459)

Melville Island, where some 2500 gallons of fuel and 600-man-day food rations had been cached in 1955. This cache had been established by DC-3 aircraft, equipped with ski wheels, in preparation for the helicopter-borne Geological Survey "Operation Franklin" (*Polar Record*, Vol. 8, No. 53, 1956, p. 157). This cache had been planned as the last of a series of bases for occupation as the operation proceeded across the Queen Elizabeth Islands. However, owing to adverse weather, the site of the cache was not occupied for any length of time, and most of the fuel and food was still available.

Map of Parry Islands, showing base camps and landing sites of Piper Super-Cub aircraft, during Geological Survey of Canada expedition, 1958.

In order to facilitate landings on unprepared terrain, Phipps equipped the aircraft with large balloon tyres, 25 by 11 by 4 in., and bearing 5 lb. pressure. These are standard equipment for the Stinson SR5, and with slight modifications the hubs of the Super-Cub wheels were adapted to fit them. The increased drag of the large tyres reduced the normal cruising speed from about 115 m.p.h. to about 95 m.p.h. The Piper Super-Cub is powered by a 150 h.p. Lycoming engine. Fuel consumption is about $6\frac{1}{2}$ Imperial gallons per hour, and the fuel tanks carry 30 gallons giving a range of 400 miles. About 200 ft, is required for take-off, and somewhat more for landing. In Canada the Super-Cub is licensed to carry a disposable load of 700 lb.

The main objects of the 1958 Survey were to delimit and describe the bedrock formations and to produce a geological map on a scale of 8 miles to the inch of the

Parry Islands. Photogeologic maps were prepared from air photographs and previously acquired geological information. From these, critical areas were selected for ground investigations.

The aircraft left Carp, Ontario, on 15 June. In order to cover long distances between refuelling points, Phipps carried an additional 45 gallons of fuel in a drum strapped behind the pilot's seat. The drum, together with full wing tanks, gave the aircraft a range of about 1000 miles. He had designed a pumping system which enabled him to fill the wing tanks from this drum while airborne. Phipps's route lay through Churchill, Baker Lake, and Shepherd Bay. On 19 June Thorsteinsson and Tozer were flown by the R.C.A.F. from Churchill to Resolute, and Phipps arrived there the same day.

On 20 June the party started the airlift to Melville Island. Five flights between Resolute and Tingmisut Lake were required to transport the geologists, their equipment and instruments to the base camp. Geological investigations started on 25 June when a camp was established on the north side of Raglan Range, north-western Melville Island. On 11 July the party moved to Mackenzie King Island and set up a camp near Leffingwell Crags Mountain. Ten days were spent on the geological study of Brock, Borden and Mackenzie King Islands. During this period a second camp was occupied in north-western Mackenzie King Island. These landings were the first visit to Brock, Borden and Mackenzie King Islands since their discovery by the Canadian Arctic Expedition, 1913–18, led by Vilhjalmur Stefansson. Between 21 and 26 July the party made its headquarters at the Mould Bay Weather Station, Prince Patrick Island, and flights were made to points on Prince Patrick and Eglinton Islands. On 26 July the party returned to Melville Island and a camp was established on the north side of Ibbett Bay. Here the party remained for four days then returned to Tingmisut Lake. After completing the geological study of Melville Island, the party started the return airlift to Resolute on 1 September. Owing to adverse weather this was not completed until 10 September.

The aircraft was also used to transport the geologists to critical outcrops, and as a vantage point from which formational contacts and other structural features could be recognized and located accurately on air photographs and maps. With one exception, Phipps was able to land within ten minutes walking distance of every locality chosen by the geologists. The one exception was caused by unusually high winds rather than unsuitable terrain. Each geologist spent one day flying and one day in camp, compiling field data and planning the following day's air traverse.

During field work, radio communication was maintained between the aircraft and the weather stations at Resolute and Mould Bay. A 2 W. radio at the main base camp made intermittent contact with the aircraft and the weather stations. Emergency and survival equipment was carried on all flights. Owing to the great distances over which the survey ranges it was necessary to set out several small caches of fuel on Mackenzie King Island, and on western Melville Island at Ibbett Bay and Cape Fisher. The aircraft was capable of carrying four 10-gallon drums at a time.

A total of 300 hours were flown during the season, including the 60 hours used in flying up to Resolute and back to Carp. Approximately 450 landings were made, of which about 400 were on unprepared landing surfaces. The aircraft landed on unprepared terrain in 249 different places. One hundred and sixty of these were on Melville Island, 29 on Mackenzie King Island, 27 on Prince Patrick Island, 15 on Borden Island, 10 on Eglinton Island, 4 on Brock Island, 3 on Cameron Island and 1 on Emerald Island.

The islands investigated comprise an area of 23,800 square miles. Parts of this area had been studied by Tozer in 1954 and 1955,[1] travelling by dog team and on

[1] *Geological Reconnaissance, Prince Patrick, Eglinton and Western Melville Islands* Geological Survey, Canada, Paper 55–5; and "*Operation Franklin*" *Report*, not yet published.

foot, but most of the area had not been previously studied by the Geological Survey.

The performance of the aircraft was satisfactory in every respect. On six occasions the aircraft became mired in mud on landing, when the entire weight of the aircraft settled on the wheels. In general, this occurred only on surfaces that would not support a man on foot. The depth to which the aircraft sank on these occasions seldom exceeded the height of the hubs, and was determined by the depth of the frost table, which in these latitudes generally lies within a few inches of the surface. The aircraft was released from the mud by one man lifting on the wing strut, while the other built a support of rocks under the tyres. In this manner the aircraft was gradually worked on to firm ground.

Three characteristics of the Piper Super-Cub that contributed to its efficiency in the 1958 Survey are: (1) the buoyancy of the large tyres on soft terrain; (2) the shock-absorbing properties of the undercarriage, which was dependent upon the soft tyres and the conventional shock absorbers; (3) the outstanding, low-speed handling characteristics that permit a safe approach and landing at an indicated speed of 35 to 40 m.p.h. Absolutely calm conditions are rare in the area, consequently most landings were made with a head wind that reduced the ground speed on landing to less than 35 m.p.h.

THE NORTHERN SEA ROUTE IN 1958

[From *Vodnyy Transport* [*Water Transport*], 11 June, 3 and 17 July, 7 August, 13 November 1958.]

It was planned to carry 25 per cent more freight in 1958 than in 1957, which gives a target figure of 2 to 2½ million tons. Seventy cargo ships were allotted for the purpose, including five of the six *Ob*'-class vessels, and, in addition, 40 non-Soviet ships embarked timber at Igarka. Seven icebreakers were employed: three *Stalin*-class, three *Kapitan*-class, and the *Yermak*.

At the Pacific end of the route the season opened earlier than usual, in early July, owing to favourable ice in the East Siberian and Chukchi Seas. A ship reached Pevek by mid-July. Ice conditions during the season were described as normal, and the last ships left Bering Strait towards the end of October. In the west, however, the Kara Sea ice was difficult, and Obskaya Guba, for instance, broke up 20 days later than normal. Sea-going ships did not arrive at Igarka until 3 August, and ice in the sector Ostrov Diksona–Proliv Vil'kitskogo (the Severnaya Zemlya ice cluster) remained difficult throughout the season. At least four ships which reached the Laptev Sea from Arkhangel'sk had to withdraw eastwards, contrary to plan.

Two passenger vessels and two dredgers for use on the Ob' reached their destination by sea. Other river craft were similarly sent to the Yenisey and Lena.

The ice-reporting service, employing 30 aircraft, for the first time used facsimile transmission of maps by radio, the necessary apparatus being installed experimentally in some aircraft and in two icebreakers. Television between aircraft and ship was in an earlier stage of experimentation.

INTERNATIONAL GLACIOLOGICAL EXPEDITION TO GREENLAND (E.G.I.G.), 1957–60: OPERATIONS IN 1958

[From information supplied by Expéditions Polaires Françaises.]

Activities in 1958 were confined to the transport and storage of supplies and equipment for use in 1959 and 1960. These were transported in the Danish vessel *Blikur* which left Le Havre on 16 October 1958 and reached Søndre Strømfjord on the 27th. The following members of the expedition travelled on *Blikur* to supervise the

unloading and storage of supplies: R. Gillard, leader of the expedition; M. de Lannurion, leader of the 1958–59 wintering party; G. Aslanoff; C. Giller and M. Grisoni.

Weather conditions obliged the vessel to anchor about 800 m. from shore, but all supplies were landed in 3 days and transported by the United States Air Force to hangers on the air base 15 km. inland.

The five members of the expedition returned to France by air on 6 November.

EXPEDITIONS OF NORSK POLARINSTITUTT TO SVALBARD AND EAST GREENLAND, 1958

[Summarized from information provided by Norsk Polarinstitutt. Accounts of earlier expeditions were given in the *Polar Record*, Vol. 9, No. 59, 1958 p. 139, and previous numbers.]

Svalbard 1958

The expedition was led by K. Z. Lundquist and consisted of thirty-seven members. One party left Åndalsnes in *Minna* on 17 June and arrived at Vestspitsbergen on the 25th. The remainder, in *Sjøvern*, sailed from Narvik on 23 June and reached Longyearbyen on the 30th.

The programme of work carried out during the season was as follows: K. Z. Lundquist in *Sjøvern* made magnetic measurements at 65 stations along the coast of Vestspitsbergen; H. M. Lind Anderson, in *Minna*, carried out hydrographic surveys, in Woodfjorden and inspected lights and radio beacons; H. Hornbæk also carried out hydrographic surveys in Breibogen; T. Askheim and W. Solheim did triangulation work at Liefdefjorden and in southern James Land, respectively; O. Liestøl continued observations on Finsterwalderbreen at Van Keulenfjorden; A. Hjelle did geological survey work in the Bellsund area; H. Major examined coal strata in areas south of Adventfjorden; and H. J. Løvenskiold made ornithological investigations on Bjørnøya.

Ice conditions in northern and eastern waters were more difficult than in any year since 1945. At the end of August *Sjøvern* and *Nordsyssel* assisted the Swedish naval ship *Älvsnabben* in the re-supply of the Swedish–Finnish–Swiss I.G.Y. station at Murchisonfjorden.

Minna left Vestspitsbergen on 30 August for Norway by way of Bjørnøya, and *Sjøvern* followed on 2 September.

Relief expedition to north-east Greenland, 1958

The annual expedition to north-east Greenland was led by Søren Richter in *Polarsel*, which left Ålesund on 24 July and returned on 7 September.

SECOND SCANDINAVIAN ARCHAEOLOGICAL EXPEDITION TO SPITSBERGEN, 1958

[From information supplied by P. Simonsen. A note on the previous expedition from Tromsø Museum appeared in the *Polar Record*, Vol. 8, No. 55, 1957, p. 348–49.]

Between 20 July and 29 August 1958 a party from Tromsø Museum carried out archaeological excavations on Midterhuken in Bellsund, Vestspitsbergen. The party consisted of Professor H. Tegengren of Åbo University as leader, N. Fritzen, K. Odner and T. Markussen. The expedition was sponsored by the Finnish and Norwegian governments. Seventeenth and eighteenth-century Dutch and Russian whaling and hunting stations were uncovered, and the existence of a number of other sites was confirmed. A map was made of all sites of archaeological interest along a 100 km. stretch of coast.

TROMSÖ MUSEUM BIOLOGICAL EXPEDITION TO SPITSBERGEN, 1958

[From a note by P. Simonsen.]

Between 5 July and 7 September a party, organized by Tromsö Museum, carried out marine biological investigations in Vestspitsbergen. Members were: B. O. Christiansen (leader), Å. Anderson and P. Hognestad, zoologists, and N. Foged, O. I. Rönning and O. Skifte, botanists.

Longyearbyen was reached on 5 July and, until 1 August, the zoologists were occupied in re-examining the marine sites in Isfjorden at which observations had been made by the Swedish *Svensksund* expedition in 1908. Later, they occupied stations from Bellsund up the west coast and along the north coast as far east as Woodfjorden.

The botanists worked from a number of camps on the coast between Isfjorden and Woodfjorden.

BRITISH UNIVERSITY ARCTIC EXPEDITIONS, 1958

Birmingham and Exeter University Spitsbergen Expedition, 1958

[Summarized from a report by P. A. Garrett.]

A party from Birmingham and Exeter Universities spent between 10 July and 25 August 1958 in the Ekmanfjorden area of Vestspitsbergen. They were P. A. Garrett, leader; D. L. Dinely, A. Horton, J. S. Jennings, T. N. Norman and P. C. Wright, all geologists; R. S. Waters, geomorphologist; and R. B. Somerset, medical officer. They had an open 18 ft. boat with an outboard motor.

Waters and Horton made a detailed study of the raised beaches of Blomesletta, on the east side of Ekmanfjorden. The remainder of the party worked on the stretch between Sveabreen and Sefstrømbreen on the west side of Ekmanfjorden, making fossil collections and investigating the Permo-Carboniferous and Mesozoic rocks in the area. Dineley made a collection of Old Red Sandstone fish on the east side of Orsabreen, north of Ekmanfjorden.

Cambridge Spitsbergen Expedition, 1958

[Summarized from information provided by P. J. Friend. Accounts of earlier Cambridge expeditions in this area appear in the *Polar Record*, Vol. 9, No. 59, 1958 p. 141 and previous numbers.]

The expedition left England on 16 June and reached Skottehytta, Billefjorden, on the 30th. It then divided into two parties. Party "A" consisted of P. F. Friend, leader, D. B. Benton, M. D. Fuller, J. C. Rucklidge, P. R. Simpson and J. C. Taylor. Their object was to continue and extend the geographical and topographical work of previous Cambridge parties in the Devonian areas of Dickson Land and Andrée Land. Party "B", consisting of D. J. Gobbett, leader, R. F. Atherton and C. J. B. Kirton, planned to carry out stratigraphical and palaeontological work in the Oslobreen area of Ny Friesland.

Party "A" sledged to Austfjorden which was filled with ice and it was not until 27 July that they were able to move up the fjord by boat to Andrée Land. While waiting, however, work was carried out in north Dickson Land. In Andrée Land a series of camps was set up along the fjord, the party moving from one to another by means of a small boat powered by outboard motors. An important collection of oriented specimens for palaeomagnetic work was made, but weather hampered topographical work. The party returned to Billefjorden on 24 August.

Party "B" left Skottehytta on 11 July and sledged to their objective on Oslobreen, arriving on the 22nd. Three days later Kirton was injured in a fall of scree and died six hours later. Atherton and Gobbett returned to Billefjorden, leaving much of their stores and equipment, and carried out geological work there until Party "A" arrived.

The main party were picked up by the *Nordsyssel* on 25 August while Friend and Fuller remained working on the Devonian sediments around Billefjorden until 11 September. They then returned to Longyearbyen.

Cambridge Nordaustlandet Expedition, 1958

[Summarized from an unpublished report by P. G. Bateson.]

An ornithological party from Cambridge University spent two months in the Wahlenbergfjorden area of Nordaustlandet during the summer of 1958, with the main object of studying Ivory Gulls (*Pagophila eburnea*). They were P. G. Bateson, J. L. Cutbill, R. E. H. Hitchcock and R. G. Plowright.

Sailing on Norsk Polarinstitutt's *Minna* from Longyearbyen, they were landed on Gyldénøyane in the mouth of Wahlenbergfjorden. The ice in the inner part of the fjord, the goal of the expedition, was too thick to enable the party to reach their destination for three weeks. Bird life on the islands, however, was surprisingly prolific and varied. Weather prevented reconnaissance trips until 10 July, when the east side of Palanderbukta was reached and, two days later, a point further up the fjord where a large colony of Ivory Gulls was discovered. On 16 July a camp was set up on the top of the cliff on which the birds were breeding. The birds were studied until 8 August. The party then returned to Longyearbyen in *Minna*.

Geological work in Oscar II Land, Vestspitsbergen, 1958

[By C. B. Wilson.]

During a visit to Vestspitsbergen in 1957,[1] C. B. Wilson spent a short time examining the Hecla Hoek rocks east of Forlandsundet and, as a result, arranged with Norsk Polarinstitutt to spend two summer seasons on a geological survey of these formations between Engelsbukta, Kongsvegen and St Jonsfjorden. His work is to continue southwards from the area surveyed by A. K. Orvin.

The area is about 300 sq. miles, most of which is ice covered. A coastal plain rises abruptly into the main mountainous area with sharp ridges and peaks occasionally exceeding 1000 m. The coast is easily navigable in a small boat owing to the abundance of good landing beaches and to the partial protection from ocean swells; the tidal currents around Sarstangen are not a problem. Several large glaciers reach the sea, but of these only Comfortlessbreen, and possibly Aavatsmarkbreen, afford easy sledge routes inland. All these glaciers show signs of marked and active retreat (Dahlbreen by at least two miles in the last 40 years). Inland the sledging is easy in the north, but hampered by crevasses in the south; the average height of the inland snow line is about 550 m. and the glaciers were snow-covered down to 400 m. in late July.

Wilson arrived in Ny Ålesund on 28 June and left the same day for Engelsbukta. His means of transport consisted of a 4 m. aluminium boat with two "Atko"

[1] *Polar Record*, Vol. 9, No. 59, 1958, p. 142.

Elisebreen, Oscar II Land, Vestspitsbergen, with coastal plain. Forlandsundet and mountains of Prins Karls Forland in background

Photograph by C. Wilson

147 outboard motors, and a 2 m. Pulka sledge with bamboo harness. An excellent sledging route, involving little back packing, was found up the south-western side of Comfortlessbreen and he worked in this area for ten days. After a day occupied in ski-ing to Ny Ålesund to collect maps and photographs he traversed the length of Comfortlessbreen and spent the next six weeks visiting inland outcrops and climbing a number of peaks, most of which had not previously been climbed. An unseasonable snow storm in early August curtailed this trip and prevented any geological work being carried out for a week.

He returned to Engelsbukta on 14 August and then set off down the coast by boat, visiting the coastal mountains from camps along the coastal plain. The weather in late August and mid-September prevented visits being made to the ranges above St Jonsfjorden. After waiting nearly a week on the southern shore of St Jonsfjorden for the wind and sea to subside, he sailed on to Longyearbyen, arriving there on 23 September.

As Wilson was travelling alone for almost three months and had to be mobile throughout the whole period, details of the food and equipment taken are of interest.

Food. Daily ration; 96 man/day rations were taken, no extras:

	Oz.		Oz.
Nut pemmican	4	Margarine	2
Bovril	1	Chocolate	6
"Aberdeen bar"	1	Cheese	2
Mixed vegetables	1	Shortbread	3
Oatmeal	5	Drinking chocolate	
Sugar (granulated)	4	Instant coffee	
Syrup	1	Salt and Curry powder	
Dried milk	1	Total:	32 oz.

Equipment:

1 4 m. aluminium boat with 1 pair of oars, no anchor
2 "Atko 147" outboard motors with a few spares
3 Jerry cans of petrol and oil, sufficient for about 250 miles
1 Pulka sledge (3 m.) with bamboo harness
1 pair skis, 3 ski sticks
2 Mummery tents
8 2 m. bamboo poles, for use as tent pegs in deep snow
1 "Radius No. 42" petrol cooker
2 gallons white petrol for cooking (1 quart per 12 days)
2 goose down sleeping bags and 1 air mattress
2 cooking pans, 2 pint capacity
1 pack frame, "Everest"
1 pair waders
Polythene bags and sheeting and polythene bottles for petrol.

North-west Spitsbergen Expedition, 1958

[Summarized from an unpublished report by E. L. Lewis.]

This expedition spent from 15 June to 10 September in Vestspitsbergen collecting specimens for palaeomagnetic measurements. About 330 orientated rock samples were collected for examination in the Sedgwick Museum, Cambridge. Members were: E. L. Lewis, leader, physicist; A. W. Williamson, deputy-leader, geophysicist; D. E. T. Bidgood, geophysicist; E. B. Davies, general duties; P. A. Roberts, photographer; and B. R. Sparke, medical officer.

Collections were made in the following areas: Festningen, Veteranen, Backlundtoppen, and the fjords leading out of the north of Isfjorden.

Hofgaardtoppen, Oscar II Land, Vest Spitsbergen, from the west

Photograph by C. Wilson

Scottish East Greenland Expedition, 1958

[From a report by M. Slessor.]

The object of this expedition was to explore and climb Staunings Alper in the Scoresby Land region of east Greenland. Some field work in zoology, botany and glaciology was also carried out. Members of the party were M. Slessor, leader; D. Bennet, K. Bryan, R. Cameron, L. Lovat, S. Paterson, C. Rose, D. Scott and I. Smart.

The party arrived at Mesters Vig by charter aircraft on 10 July. For the first two weeks the party visited Bersærkerbræ and climbed five previously unclimbed peaks on the eastern side of the mountains. When the ice in the fjord broke up, about the end of July, the party moved to the head of Alpefjord from which it visited Sefströms Gletscher, Spæviegletscher and other glaciers leading into Schaffhauserdalen. Eighteen peaks were climbed and the ridge crosed in a north to south direction for the first time. On the return to Mesters Vig the range was crossed by way of Gullygletscher and Bersærkerbræ.

Cambridge West Greenland Glaciological Expedition, 1958

[Summarized from a report by T. A. Henry.]

A six-man party from Cambridge University spent three months in west Greenland during the summer of 1958 studying the formation of wave ogives on Lyngbræ, a glacier flowing from the Sukkertoppen ice cap to Søndre Strømfjord. Members were: T. A. Henry, leader, A. R. Archer, D. L. Atherton, A. Morrison, G. S. White, R. J. White.

Arriving at Sukkertoppen on 28 June the party covered the last 50 miles along the coast and up Søndre Strømfjord in a fishing boat. A base camp was established about 400 yards from the fjord and, later, a working camp near the snout of the glacier. There a series of wooden stakes was drilled into the ice along a line down the glacier, parallel to the direction of flow. Fixed theodolite positions were set up on the rock walls of the valley at one side of the glacier and three surveys, at 20-day intervals, were carried out of the positions of each stake relative to its neighbours and to the rock wall. Other features of the glacier, which might bear on the formation of the ogives, were also examined. Brief studies of neighbouring glaciers were also made. These ogives on Lyngbræ had a mean amplitude of up to 60 ft.

The party returned to Sukkertoppen on 8 September and a few days later flew back to København.

FRENCH–SWISS EXPEDITION TO WEST GREENLAND, 1958

[Summarized from a report on the expedition by R. Dittert.]

A party of five French and Swiss mountaineers spent August 1958 climbing in the Sukkertoppen area of west Greenland. They were: R. Bretton, R. Dittert, R. Greloz, V. Lasserre and R. Tissieres. The first camp was set up on Ikamiut Kangerdluarssuat on 4 August and, on the 5th and 7th, two nearby peaks were climbed, each for the first time. The party moved to Agparmiut Kangerdluarssuat and climbed Quinguataqáqai, then a peak in the region of Suilaersarfik, also both for the first time. Camp was then moved to Kanguissaq on Evighedsfjord and five first ascents made of peaks in the area; the highest, Agssaussat, being 2140 m.

The party left Sukkertoppen for Søndre Strømfjord on 3 September.

EVACUATION OF UNITED STATES I.G.Y. DRIFTING STATION "A", 1958

[Summarized from the *Times* and *New York Times* of 8 and 10 November 1958.]

Twenty members of a United States I.G.Y. and Naval supporting party were taken off by air from the United States Arctic Drifting Station "A" on 7 November 1958. When the drifting station was established in 1957 (*Polar Record*, Vol. 9, No. 60, 1958, p. 241–42) the ice floe measured about two miles by five miles. A violent storm in August 1958 reduced the area considerably and several subsequent storms split the floe, necessitating the moving of the camp buildings three times. A final storm, early in November, reduced the length of the runway to 2200 ft. (670 m.) and made further occupation of the station impracticable. The station commander at the time was Captain J. H. Smith, U.S.N., and the scientific leader G. Cvihanovich, Columbia University.

The aircraft used to evacuate the party was a wheel-equipped Skymaster of the Alaska Air Command, piloted by Captain J. B. Sullivan, U.S.A.F. To assist in rapid take-off the aircraft was equipped with two auxiliary jet engines.

THE USE OF HELICOPTERS IN TERRE ADELIE, 1957 AND 1958

[By B. Imbert, Chief des Expéditions Antarctiques Année Géophysique.]

During the Antarctic summer operations of 1957 and 1958, the French Antarctic I.G.Y. expeditions have made use of a B47G2 helicopter.

The machine was brought from France on the after deck of the *Norsel*, protected in a cocoon against sea spray. On arrival at "Base Dumont d'Urville" she was put in working order in one day, and flown from *Norsel* to a base on Île des Pétrels for the season. The staff consisted of two pilots and two mechanics under the command of Commandant Petitjean, who had had experience in Îles Crozet and Îles de Kerguelen, where he had carried out flights with a Hiller helicopter in 1956 and a Djinn helicopter in 1957.

The flights made were of two types: (1) At Île des Pétrels, to take material from the landing place to various depots on the island, particularly those difficult of access by vehicle. This was usually carried out at the rate of about 3 tons an hour and produced no particular problems. The load carried at one time was about 330 kg. (2) Transport from Île des Pétrels to depots on the mainland to avoid carriage by sea and over the main area of crevasses. These depots were generally 20 to 40 km. south-west from "Base Dumont d'Urville". For these flights more serious difficulties were faced as the single machine was working to the limit of its capacity. The load was reduced to 200 kg. including radio and survival kit. This kit weighed about 40 kg. and included a tent, sleeping bag, a cooker and 15 day's rations. It saved the life of the pilot Berthe when he crashed on 27 January 1958, and stayed in a blizzard for two days before being rescued.

The main difficulties during Antarctic flights are navigation, wind and whiteout; in summer the cold is not inconvenient. In navigation reckoning is difficult, in fact it is impossible to hold a course exactly in a helicopter; in addition the lightness of the machine results in the wind making it drift very considerably. Landmarks on the ground hardly exist. Obvious marks like caterpillar tracks are almost immediately covered by one of the perpetual blizzards of Terre Adélie, and the small flags marking tracks can only be seen at the risk of flying low. In order to save weight an altimeter is not carried, and a magnetic compass is useless owing to the proximity of the Magnetic Pole (the component horizon of "Base Dumont d'Urville" is about

0·004 gauss). As the directional gyro lacked slow precession it was necessary to adjust it by means of an astro compass or, more simply, by the use of tables of sun azimuths. Radio, in particular a simple homing device, is the basic safeguard; unfortunately the radio broke down and could not be used for this purpose.

The wind, particularly the catabatic wind common in Terre Adélie, is unpredictable and comes in sudden bursts often reaching 50 knots (we have seen it up to 140 knots, and the annual mean at Port Martin is 37 knots). In such conditions it is necessary to handle a machine quickly to be able to return into the wind; often the Bell helicopter, of which the maximum speed is 60 knots, did not make more than 10 to 15 knots ground speed, and had difficulty in returning to base. At times, however, when unloading was halted by winds of 25 knots, and vehicle convoys by winds of 30 knots, the helicopter could fly in winds of up to 40 knots, and possessed the additional advantage of allowing the pilot to see through the blizzard from above when the view from the ground would be totally obscured.

Whiteout was the most dangerous hazard and was the cause of the accident in January 1958 when a Bell helicopter crashed about 30 km. from "Base Dumont d'Urville".

Results, It is estimated that in the carrying of loads on Île des Pétrels the helicopter performed work equivalent to 500 man days and that, during the summer season, it saved the expedition about a month's work.

It was also extremely useful in providing liaison between shore and the expedition ship.

On the other hand, it was not safe to send it for journeys of more than 50 km. inland without having a rescue aircraft.

The work done during the two Antarctic summer seasons is summed up in the following table:

Year	Length of stay	Hours of flight	Weight transported (in kg.) At "Base Dumont d'Urville"	Weight transported (in kg.) On the mainland
1957	50 days	167	50,000	21,000
1958	30 days	96	96,000	16,000

During the 1959 summer season two Djinn helicopters are to be used, again under the command of Commandant Petitjean.

NOTES

ICEBREAKER CONSTRUCTION IN FINLAND

[Information supplied by Wärtsilä-Koncernen A/B, Helsingfors.]

Icebreaker construction at the shipyard of Wärtsilä-Koncernen A/B in Helsingfors is continuing.[1] Of the two diesel-electric ships of 22,000 s.h.p. due to be built for the U.S.S.R., one, the *Moskva*, was launched on 10 January 1959, and the keel of the sister ship was laid down on the same berth four days later. *Moskva* will be ready for delivery in the summer of 1960. Both ships will be for service on the Northern Sea Route. The particulars vary slightly from the preliminary figures given in an earlier issue,[2] and are as follows: normal displacement 13,290 metric tons; overall length 122.1 m. (400 ft.); moulded beam 24·5 m. (80 ft.); maximum draught 10·5 m. (34 ft.); screws 3 (all aft); speed 18·3 knots.

In addition, the firm is building for the Finnish Government a new class of 7500 s.h.p. diesel-electric icebreakers. The first, named *Karhu*, was delivered in the autumn of 1958; the second, *Murtaja*, was launched at that time and should be delivered in the autumn of 1959; and the contract for a third was signed in February 1959. Particulars are as follows: Normal displacement 3370 metric tons; overall length 74·15 m. (243 ft.); moulded beam 17·4 m. (57 ft.); draught 5·8 m. (19 ft.); screws 2 fore, 2 aft.

INTERNATIONAL WHALING CONFERENCE, 1958

[From information supplied by the Ministry of Agriculture, Fisheries and Food.]

Representatives of the Governments of the five nations engaged in Antarctic pelagic whaling, namely, Japan, the Netherlands, Norway, the United Kingdom and the U.S.S.R., met in London in November 1958 and agreed to recommend to their governments an agreement among the five nations for the conduct of Antarctic pelagic whaling as follows:

1. That in the interest of the rational conduct of the Antarctic pelagic whale fishery under the International Whaling Convention of 1946 a scheme shall be negotiated providing for the allocation of the annual total catch authorized under the Convention among the five nations now engaged in the fishery.
2. That the scheme shall cover the seven-year period beginning with the 1959–60 Antarctic pelagic whaling season.
3. That during this seven-year period the U.S.S.R. may add not more than three new factory ships to their existing fleet operating in the Antarctic; but that with this exception none of the five nations shall increase the number of its factory ships operating in the Antarctic during the seven-year period, other than by purchase one from another of factory ships engaged at the time of purchase in Antarctic pelagic whaling.

[1] *Polar Record*, Vol. 8, No. 55, 1957, p. 366.
[2] *Polar Record*, Vol. 8, No. 52, 1956, p. 47.

4. That none of the factory ships belonging to the five countries shall be transferred to another country, being party to the Convention, unless a proportionate part of the quota of the vendor's country is transferred to the purchaser's country which shall agree to accept the obligations of this agreement, or unless the purchaser gives a satisfactory guarantee that the factory ship will not be used as such in Antarctic pelagic whaling during the seven-year period of this agreement.

5. That 20 per cent of the annual total catch authorized under the Convention shall be allocated to the U.S.S.R. and that the remaining 80 per cent of the authorised total catch shall be divided among the four other nations in a manner satisfactory to them.

6. That if a factory ship under any other flag should enter the Antarctic pelagic whale fishery (otherwise than as provided in clause 4) and the Government of the flag country is or becomes party to the International Whaling Convention, the agreement between the present five nations shall be null and void.

The discussions as to the allocation among Japan, the Netherlands, Norway and the United Kingdom of the total share available to them are to be concluded with a view to the agreement among the five nations being finalised before 1 June 1959.

Toru Nakagawa
For the Japanese Delegation
L. de Waal
For the Netherlands Delegation
Gustav Sjaastad
For the Norwegian Delegation

A. Ishkov
For the Delegation of the Union of Soviet Socialist Republics
J. B. Godber
For the Delegation of the United Kingdom of Great Britain and Northern Ireland

London,
27 November 1958

NEW SOVIET WHALING FACTORY SHIPS

[From *Hvalfangstliv*, 1957, Nr. 3/4, p. 27, and *Vodnyy Transport* [*WaterTransport*], 24 January 1959.]

The new factory ship *Sovetskaya Ukraina* was launched on 23 January 1959 at Nikolayev, on the Black Sea. The first ship of this type to be built in the U.S.S.R., she will displace 44,000 tons. Two Burmeister and Wain diesel engines, with a combined capacity of 15,000 h.p., will give her a speed of 16 knots. She is expected to leave for the Antarctic in the autumn of 1959, together with a flotilla of new diesel-electric catchers. The same yard is now starting work on conversion of the ex-German liner *Hamburg* (22,000 gross registered tons, completed in 1926) into a factory ship. She will be called *Yuriy Dolgorukiy*.

CIRCUMPOLAR CONFERENCE, KØBENHAVN, 1958

[From information supplied by H. Larsen.]

A Circumpolar Conference was held in Nationalmuseet, København, from 19 to 21 May 1958 with Dr Kaj Birket-Smith as chairman. Lectures, followed by discussions, were given on archaeological, ethnological and anthropological problems in Alaska, Canada, Greenland and Siberia. A number of suitable subjects for future investigation were agreed upon, also the desirability of further similar meetings and of international co-operation in Arctic research.

Members of the conference were: R. S. McNeish (Canada); K. Birket-Smith,

E. Holtved, Count Eigil Knuth, H. Larsen and J. Meldgaard (Denmark); A. Hirsjärvi, H. Tegengren (Finland); G. Gjessing, P. Simonsen (Norway); S. Janson, C.-A. Moberg (Sweden); H. B. Collins, J. L. Giddings, E. Harp, F. Rainey and I. Skarland (U.S.A.); G. F. Debets, M. G. Levin, A. P. Okladnikov and S. P. Tolstov (U.S.S.R.). Professor H. G. Bandi of Switzerland attended as an observer.

Papers were read by: R. S. McNeish, K. Birket-Smith, H. Larsen, G. Gjessing, G. F. Debets, M. G. Levin, A. P. Okladnikov, C.-A. Moberg, J. L. Giddings and E. Harp.

BROADCASTING ORGANIZATION IN GREENLAND

[From an article by K. Budde Lund in *Grønland*, 1958, Nr. 5, p. 179–87, and *Berlingske Tidende*, 23 July and 15 August, 1958.]

Den grønlandske Radiofoni, the Greenland broadcasting organization, started its first service in Godhavn in 1926. The same year it was extended to Godthåb, and in 1931 to Julianehåb. In 1940, when Greenland was cut off from Denmark as a result of the German occupation, a United States transmitter was installed in Godthåb at the telegraph station. Although it was set up as a radio telephone transmitter, and was not strictly suitable for broadcasting purposes, it provided a much appreciated broadcasting service from 1942 onwards. The transmitter's power, however, was only 1 kW., and reception was poor north of Holsteinsborg and south of Frederikshåb.

In 1956 a new transmitting station was built on Kookøerne, a group of islands about 25 km. south-west of Godthåb. It has a power of 25 kW. A new studio and administration building has been erected in Godthåb itself. Connexion between Godthåb and the transmitter is by V.H.F. radio telephone. To ensure satisfactory reception in the remotest parts of Greenland relay stations, with a power of 5 kW. each, have been set up at Godhavn and Frederikshåb.

The broadcasting service was previously under the direction of the editor of *Grønlandsposten*, but a separate director has now been appointed. He is Frederik Nielsen, a teacher and a Greenlander. The Danish Statsradiofoni has lent two experts for two years, one on the programme side and one to help with technical aspects of the studio work. Among the new staff are four Greenlanders who have received training in Denmark at Statsradiofonien.

It is planned to broadcast for about $8\frac{1}{2}$ hours daily between 07·30 and 23.00 hrs. Under the old system the allocation of programmes was as follows: broadcasts in Greenlandic, 27 per cent; broadcasts in Danish 12 per cent; music 61 per cent. Under the new plan it is: Greenlandic 42·4 per cent, Danish 15·4 per cent, music 42·2 per cent.

TRANS-ARCTIC COMMERCIAL FLIGHTS, 1958

[From information provided by K.L.M. Royal Dutch Airlines and Canadian Pacific Airlines.]

In November 1958 K.L.M. Royal Dutch Airlines began a trans-Arctic service between Amsterdam and Tokyo. The inaugural flight left Amsterdam at

21·40 hr. G.M.T. in a D.C.-7C aircraft, captained by Captain A. D. Snitslaar. After an hour at Stavanger the aircraft reached Anchorage at 14·55 hr on 2 November, stayed there for 1½ hours, and arrived at Tokyo at 04·35 hrs. on 3 November. Captain G. J. de Haas was in control between Anchorage and Tokyo. The return flight left Tokyo at 07.23 hr. G.M.T. on 4 November and, after stops at Anchorage and Stavanger, reached Amsterdam at 15.08 hr. G.M.T. on 5 November. The service is at present twice weekly in each direction and the aircraft used are DC-7C.

From 22 May Canadian Pacific Airlines introduced Bristol Britannia turbo-propellor aircraft on their route between Amsterdam and Vancouver. The inaugural flight between Vancouver and Prestwick, over the North Pole, carrying 64 passengers and a crew of 8, was made in 13 hr. 9 min. These aircraft make the journey from Vancouver to Amsterdam non-stop and stop once for refuelling at Frobisher, Baffin Island, on the return trip from Europe.

RECORD OF GERMAN ARCTIC EXPEDITION, 1929–30

[From information supplied by R. Thorsteinsson.]

On 1 June 1957, R. Thorsteinsson visited Meighen Island during the course of a geological survey and found, on the north-west extremity of the island, the cairn built by V. Stefansson when he discovered the island on 23 July 1916 (*Polar Record*, Vol. 9, No. 60, 1958, p. 240). In the upper part of the cairn was a solder-sealed canister containing the following messge left by H. K. E. Krüger, the German geologist and leader of the expedition:

"Die Deutsche Arktische Expedition erreichte diesen Punkt, von der Nordspitze von Heiberg-Land kommend, am 5. Mai 1930 und fand den Bericht von Stefansson. Eine Abschrift konnte nicht gemacht werden da der Bericht in so schlechtem Zustande ist, dass er nicht geöffnet werden konnte, ohne ihn zu zerstören.

Wir gehen weiter nach Kap Sverre auf Amund Ringnes-Island.

Mai 6. 1930
Age Rose Bjare
AKQIOQ

H. K. E. Krüger
Leiter "

[The German Arctic Expedition reached this point, coming from the north point of Heiberg Land, on 5 May 1930 and found Stefansson's message. A copy could not be made, since the message is in such bad condition that it could not be opened without being destroyed.

We are going on towards Cape Sverre on Amund Ringnes Island.

6 May, 1930
Age Rose Bjare
AKQIOQ

H. K. E. Krüger
Leader]

Previously the last record of Krüger, his Danish assistant, and an Eskimo driver had been a message discovered in April 1932 by a search party of Royal Canadian Mounted Police in a cairn at Cape Thomas Hubbard, Axel Heiberg Island (*Polar Record*, Vol. 1, No. 8, 1934, p. 121–29). This was dated

30 April 1930 and said that the party were on their way to Meighen Island. It now appears that they did reach the island and then set out for Cape Sverre, on the northern shore of Amund Ringnes Island.

NEW RECORD LOW TEMPERATURE

[Summarized from *Pravda*, 14 September 1958.]

A new record low temperature of −87·4° C. (−125·3° F.) was established at the Soviet Antarctic station "Vostok" on 25 August 1958.

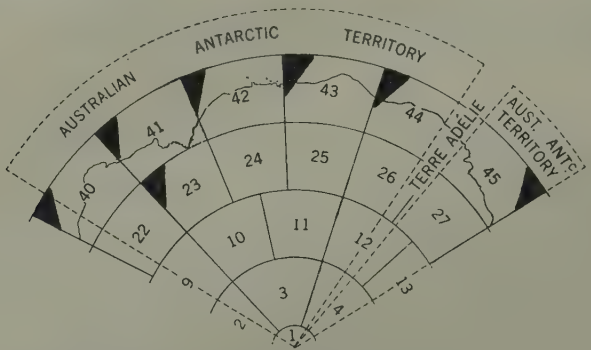
AUSTRALIAN MAPS OF ANTARCTICA

A second edition of the general map of Antarctica, scale 1:10,000,000, produced by the National Mapping Office, Department of the Interior for the Antarctic Division, Department of External Affairs, was published in 1956.[1] The first edition appeared in 1939 and comparison of the two maps shows not only that many more named features have been added to the latest map, but that much of the previously unexplored coast (a dotted line in the 1939 edition) has been filled in. The map is clearly produced in colour on an azimuthal equidistant projection. Lettering is in blue and black, mountains are lightly etched in brown, and ice fronts are drawn with the date of their latest known position. Those political boundaries recognized by Australia are shown, and place-names are those of the administrative authorities of the different sectors. The two inset maps are retained: one, scale 1:7,000,000, of the coastal regions of the Australian Antarctic Territory, and the other, scale 1:60,000,000, showing the Antarctic continent in relation to the principal land masses in the southern hemisphere. Dates of the discovery of various parts of the continent are given with the name of the discoverer. Bathymetry is shown in ten shades of blue and soundings are also marked. The map measures 75·5 × 99 cm.

In 1958 the first sheets of the new series of maps of Australian Antarctic Territory, scale 1:2,000,000, were published by the Division of National Mapping, Department of National Development, for the Antarctic Division, Department of External Affairs. The sheets measure 45·5 × 33 cm. and are produced on a polyconic projection. Survey work by the Australian National Antarctic Research Expeditions, 1955–58; by Expéditions Polaires Françaises, 1948–53, and by other expeditions has been used in compilation and control. The index shows the published sheets to December 1958. Place-names are those approved by the Antarctic Names Committee of Australia for official publications in Australia, and therefore in the United Kingdom and New Zealand also. Printing is in blue (for ice and marine features) and black (for land features, boundaries, etc.). Form lines, with a 200 m. vertical interval are shown in some sheets.

[1] See also: The Australian map of Antarctica, *Geographical Journal*, Vol. 123, Part 1, 1957, p. 82–83, by Brian Roberts. Contemporary cartography: Antarctica, 1:10,000,000, Zenithal equidistant projection. *Cartography*, Vol. 2, No. 1, 1957, p. 6–8.

A map of the Vestfold Hills, scale 1:100,000, was published in September 1958 by the Division of National Mapping, Department of National Development, for the Antarctic Division, Department of External Affairs. The large ice-free land area is shown in pale yellow. Printing is in blue (for ice and marine features) and black (for land features). Contours and form lines are drawn at 25 m. intervals. The map is produced on a polyconic projection and compiled from vertical air photographs using slotted template assembly. The map measures 45·5 × 34·75 cm.



Index to sheets of Australian 1:2,000,000 map of Australian Antarctic Territory. Sheets published at 31 December 1958 are indicated by black corners.

S.C.A.R. BULLETIN

No. 2, May 1959

International Antarctic Analysis Centre

Australia has accepted the invitation of S.C.A.R. to establish an International Antarctic Analysis Centre in Melbourne. The Centre will be set up by the Australian Bureau of Meteorology as a laboratory for the analysis of the synoptic charts of the area of the southern hemisphere south of lat. 30° S.

2. It is hoped that the Analysis Centre will begin operations on a preliminary scale on 2 February 1959.

3. It is obvious that the success of the Analysis Centre will depend largely on communications. It is hoped to have reports from Antarctica, South America, South Africa and other stations south of lat. 30° S. available in Melbourne within six hours of the time of observation. The S.C.A.R. Working Group on Communications is examining this and related problems. It is anticipated that the Analysis Centre will, at first, make use of existing communication facilities, but it is obvious that this should be regarded as a temporary expedient. It is presumed that the Japanese station on the Antarctic continent will report on the "mother–daughter" network as formerly, until a new communication plan is evolved. However, if radio communication could be established with the Australian station "Wilkes" this would be of considerable advantage to the operation of the Analysis Centre.

4. Another important factor is that there should be adequate and competent analyst capacity. The Director of the Australian Bureau of Meteorology has emphasized to S.C.A.R. that Governments should actively collaborate by sending competent meteorologists to work in the Centre.

Membership of Working Groups

Antarctic cartography

Argentina	L. Picard, head of division of cartography, Instituto Antártico Argentino, Buenos Aires.
Australia	B. P. Lambert, Director of National Mapping, Department of National Development, Acton, Canberra.
Belgium	J. Loodts, c/o Comité special belge de la Recherche dans l'Antarctique, Administration de la Récherche Scientifique, Ministère de l'Instruction Publique, Residence Palace, Rue de la Loi 155, Bruxelles.
France	Ing. Gen. G. R. Laclavere, 30 Avenue Rapp, Paris 7.
Japan	Dr Kunihiko Sino, Chief, Topographic Division, Geographical Survey Institute, 7–1000, Kamimeguro, Meguro-ku, Tokyo.
New Zealand	R. G. Dick, Surveyor-General, Lands and Survey Dept., Wellington.
United Kingdom	Brigadier M. Hotine, Directorate of Overseas Surveys, Kingston Road, Tolworth, Surrey.

U.S.A.	G. D. Whitmore, Chief Topographic Division U.S. Geological Survey, Washington.
U.S.S.R.	B. V. Dubovskoy, Chief Aerophotographic Division of Sojuzmorproekt.

Antarctic radio communications

Argentina	Captain Enrique G. M. Grunwaldt, Cerrito 1248, Buenos Aires.
Australia	J. F. Ward, Postmaster General's Dept., Treasury Place, Melbourne.
Belgium	H. Vandevelde, Comité special belge de la Recherche dans l'Antarctique, Administration de la Recherche Scientifique, Ministere de l'Instruction Publique, Residence Palace, Rue de la Loi 155, Bruxelles.
France	S. Emery, Comité National Français des Recherches Antarctiques, 13 rue de l'Université, Paris VII°.
Japan	Dr Yuichiro Aono, Vice-director of the Radio Research Laboratories, Ministry of Posts and Telecommunication, Kokubunji P.O., Kitatama-gun, Tokyo.
New Zealand	T. R. Clarkson, Superintending Engineer, Chief Engineers Office, Post and Telegraph Dept., Wellington.
South Africa	F. J. Hewitt, Director, National Telecommunications Research Laboratory, Pretoria.
United Kingdom	A. H. Sheffield, Colonial Office, Sanctuary Buildings, Gt. Smith Street, London, S.W.1 (Chairman).
U.S.A.	John M. Jones, National Academy of Sciences, National Research Council, 2101 Constitution Avenue, Washington 25, D.C.
U.S.S.R.	A. M. Driatsky.
World Meteorological Organization	V. Sundaram, W.M.O. Secretariat, Avenue de la Paix, Campagne Rigot, Genève.

Scientific stations in Antarctica, 1959

Argentina

Ellsworth

Location: lat. 77° 43′ S., long. 41° 07′ W., 40 m. above sea level.
Site: on ice shelf. Method of supply, by sea.
Climate: Temperature, mean annual −15·1° C., max. 1·8° C., min. −55·6° C.
Wind, mean annual, 5 m./s., extreme 28 m./s.
Cloudiness, mean annual 6·1.
Facilities available: 17 buildings accommodating 29.
Electric power: 166 kW.
Tractors, etc.: 6 Sno-cats, 4 tractors, D-4, 5 Weasels.
Personnel: Leader, J. H. Suarez.
Scientists in charge of disciplines: A. Antinucci, physiology; J. C. L. Perez, biology; W. P. Johnson and A. R. Mankewicz, meteorology.
Total, 4 scientists, 16 technicians, 9 others.
Scientific programme: Auroral physics, biology, cosmic rays, geomagnetism, glaciology, ionosphere, meterorology—surface and upper atmosphere, physiology.

Decepción

Location: lat. 62° 59′ S., long. 60° 43′ W., 7 m. above sea level.
Site: on rock. Method of supply, by sea.

Climate: Temperature, mean annual −2·7° C., max. 10° C., min. −30° C.
Wind, mean annual 6 m./s.
Cloudiness, mean annual 6·8 oktas.
Precipitation, estimated annual water equivalent 407 mm.
Facilities available: 5 buildings, accommodating 20.
Electrical power: 30 kW.
Personnel: Leader, R. C. Castouina.
Total: 1 scientist, 10 technicians, 9 others.
Scientific programme: Auroral physics (visual observations only), biology, glaciology (snow measurements only), ionosphere, meteorology—surface and upper atmosphere, physiology, seismology, atmospheric electricity.

Almirante Brown
Location: lat. 64° 53′ S., long. 62° 53′ W., 7 m. above sea level.
Site: on rock. Method of resupply, by sea.
Climate: Temperature, mean annual −2·4° C., max. 10° C., min. −21·6° C.
Wind, mean annual 2 m./s.
Cloudiness, mean annual 6·4 oktas.
Precipitation, estimated annual water equivalent, 899 mm.
Facilities available: 3 buildings, accommodating 7.
Electrical power: 10 kW.
Personnel: Leader, L. J. Rodriguez Varela.
Scientist: J. P. Alvarez, physiology and biology.
Total. 1 scientist, 3 technicians, 3 others.
Scientific programme: Auroral physics (visual observations), biology, glaciology (snow measurements only), meteorology—surface and upper atmosphere, oceanography, physiology, air chemistry.

Teniente Camara
Location: lat. 62° 36′ S., long. 59° 54′ W., 22 m. above sea level.
Site: on rock. Method of supply, by sea.
Climate: Temperature, mean annual −2·4° C., max. 9° C., min. −30° C.
Wind, mean annual 4·7 m./s.
Cloudiness, mean annual 6·5 oktas.
Precipitation, estimated annual water equivalent, 780 mm.
Facilities available: 6 buildings accommodating 7.
Electrical power: 14 kW.
Personnel: Leader, E. D. Mignone.
Scientist in charge, A. Mosca, physiology and biology.
Total: 1 scientist, 3 technicians, 3 others.
Scientific programme: Auroral physics (visual observations only), biology, glaciology (snow measurements only), meteorology—surface, physiology, air chemistry.

Melchior
Location: lat. 64° 20′ S., long. 62° 59′ W., 8 m. above sea level.
Site: on rock. Method of supply, by sea.
Climate: Temperature, mean annual −3·4° C., max. 9·2° C., min. −29·6° C.
Wind, mean annual 3·3 m./s.
Cloudiness, mean annual 6·1 oktas.
Precipitation, estimated annual water equivalent 1189 mm.
Facilities available: 6 buildings, accommodating 9.
Electrical power: 12 kW.
Personnel: Leader, C. Beis.
Total: 1 scientist (physiology and biology), 4 technicians, 4 others.

Scientific programme: Auroral physics (visual observations), biology, glaciology (snow measurements only), meteorology—surface and pilot balloon observations, oceanography, physiology, air chemistry.

General Belgrano

Location: lat. 77° 58′ S., long. 38° 48′ W., 37 m. above sea level.
Site: on ice shelf. Method of supply, by sea.
Climate: Temperature, mean annual, −21·6° C., max. 3° C., min. −50·4° C.
Wind, mean annual 5·7 m./s.
Cloudiness, mean annual 4·6 oktas.
Facilities available: 4 buildings, accommodating 17.
Tractors, etc.: 3 Weasels.
Personnel: Leader, P. P. Arcondo.
Scientist in charge, J. L. Rojo (physiology).
Total: 1 scientist, 2 technicians, 14 others.
Scientific programme: Auroral physics (visual observations only), cartography, glaciology (snow measurements only), meteorology—surface and pilot balloon observations, physiology.

Esperanza

Location: lat. 62° 23′ S., long. 56° 59′ W., 7 m. above sea level.
Site: on rock. Method of supply, by sea.
Climate: Temperature, mean annual 5·3° C., max. 14·6° C., min. −32·1° C.
Wind, mean annual 9 m./s.
Cloudiness, mean annual 6 oktas.
Facilities available: 6 buildings, accommodating 15.
Tractors, etc.: 1 Weasel.
Personnel: Leader, I. Carro.
Scientist-in-charge, P. Baeza (physiology and biology).
Total: 1 scientist, 2 technicians, 12 others.
Scientific programme: Auroral physics (visual observations only), biology, cartography, glaciology, meteorology—surface and pilot balloon observations, physiology, air chemistry.

General San Martin

Location: lat. 68° 08′ S., long. 67° 08′ W., 5 m. above sea level.
Site: on rock. Method of supply, by sea.
Climate: Wind mean annual 4·8 m./s.
Precipitation, estimated annual water equivalent 433 mm.
Facilities available: 13 buildings, accommodating 11.
Tractors, etc.: 2 tractors, 1 Weasel.
Personnel: Leader, J. A. Tagliani.
Scientist-in-charge, C. Ramaciotti (physiology and biology).
Total: 1 scientist, 3 technicians, 7 others.
Scientific programme: Auroral physics (visual observations only), biology, cartography, meteorology—surface and pilot balloon observations, physiology.

Orcadas

Location: lat. 60° 45′ S., long. 44° 43′ W., 4 m. above sea level.
Site: on rock. Method of supply, by sea.
Climate: Temperature, mean annual −4·5° C., max. 12·2° C., min. −40·1° C.
Wind, mean annual, 5 m./s.
Cloudiness, mean annual 7·2 oktas.
Precipitation, estimated annual water equivalent, 409 mm.
Facilities available: 9 buildings, accommodating 11.
Electrical power: 17 kW.

Personnel: Leader, E. Filipich.
Scientist-in-charge, J. Lahan (biology and physiology).
Total: 1 scientist, 7 technicians, 3 others.
Scientific programme: Auroral physics, (visual observations only), biology, geomagnetism, glaciology (snow measurements only), meteorology—surface and pilot balloon observations, physiology.

Australia

Macquarie Island
Location: lat. 54° 30′ S., long. 158° 57′ E., 6 m. above sea level.
Site: on sandy isthmus. Method of supply, by sea.
Climate: Temperature, mean annual 4·5° C., max. 11·5° C., min. −9° C.
Wind, mean annual 9·5 m./s., extreme 48·5 m./s.
Cloudiness, mean annual 82 per cent.
Precipitation, estimated annual water equivalent, 160 mm.
Facilities available: 41 buildings, accommodating 17.
Electrical power: 47 kW. including Radar (17 KNA), and spare unit of 15 kW.
Tractors: 1 D4 Caterpillar.
Personnel: Leader, T. R. Harwood.
Scientists in charge of disciplines: B. G. Bell, ionosonde; S. Csordas, biology; J. Hollingsworth, geomagnetism, seismology, gravity; J. Munro, cosmic rays; P. R. H. Sulzberger, auroral physics.
Total: 4 scientists, 4 technicians, 4 weather observers, 5 others.
Scientific programme: Auroral physics, biology, cartography, cosmic rays, geomagnetism, gravity, ionosphere, meteorology—surface and upper atmosphere oceanography, seismology, ozone whistlers.

Mawson
Location: lat. 69° 36′ S., long. 62° 53′ E., 6 m. above sea level.
Site: on rock. Method of supply, by sea.
Climate: Temperature, mean annual −10° C., max. 7° C., min. −30° C.
Wind, mean annual 11·5 m./s., extreme 50 m./s.
Cloudiness, mean annual estimated 55 per cent.
Precipitation, estimated annual water equivalent, 70 mm.
Facilities available: 29 buildings, accommodating 24.
Electrical power: 70 kW., spare 15 kW., and 6 emergency kW. units.
Aircraft: 2 Beaver.
Tractors, etc.: 3 D4 Caterpillar, 1 T.C.A. 20 Ferguson, 1 Sno-cat.
Personnel: Leader, J. M. Bechevaise.
Scientists in charge of disciplines: G. M. Budd, physiology; R. Dunlop, cosmic rays; M. Kirton, geomagnetism, seismology; D. J. Norris, auroral physics; B. H. Stinear, geology; F. van Hulssen, ionosonde; E. I. Widdows, meteorology.
Total: 6 scientists, 4 technicians, 2 pilots, 2 weather observers, 10 others.
Scientific programme: Auroral physics, biology, cartography, cosmic rays, geology, geomagnetism, glaciology, gravity, ionosphere, meteorology—surface and upper atmosphere, physiology, seismology.
An auroral observatory for all-sky camera parallactic photography, also used as a weather observation station, is located in lat. 67° 28′ S., long. 60° 53′ E., on the Taylor Glacier. It is manned during the winter from Mawson.

Davis
Location: lat. 68° 34′ S., long. 77° 57′ E., 12 m. above sea level.
Site: on rock. Method of supply, by sea.

Climate: Temperature, mean annual −9° C., max. 6° C., min. −32° C.
Wind, mean annual 5 m./s., extreme 45 m./s.
Cloudiness, estimated 65 per cent.
Precipitation, estimated annual water equivalent, 120 mm.
Facilities available: 13 buildings, accommodating 8.
Electrical power: 30 kW. and spare 15 kW. unit.
Tractors: 1 TCA 20 Ferguson.
Personnel: Leader, H. O. Steiger.
Total: 2 technicians, 4 weather observers, 2 others.
Scientific programme: Biology, glaciology, meteorology—surface and upper atmosphere.

Wilkes
Location: lat. 66° 15′ S., long. 110° 31′ E., 9 m. above sea level.
Site: on rock. Method of supply, by sea.
Climate: Temperature, mean annual −9° C., max. 8° C., min. −33° C.
Wind, mean annual 5 m./s., extreme 47·5 m./s.
Cloudiness, mean annual, estimated 65 per cent.
Facilities available: 18 buildings, accommodating 25.
Electrical power: 60 kW. and spare 60 kW.
Tractors, etc.: 1 D4 Caterpillar, 5 X955 Caterpillar, 2 trucks, 1 carry lift.
Personnel: Leader, W. R. J. Dingle.
Scientists in charge of disciplines: J. V. Denholm (chief), auroral physics; G. de la Harpe, ionosonde; H. L. Hansen, meteorology; R. L. Penney, biology; R. Underwood, geomagnetism, seismology.
Total: 5 scientists, 4 technicians, 3 weather observers, 5 others.
Scientific programme: Auroral physics, biology, geomagnetism, glaciology, gravity, ionosphere, meteorology—surface and upper atmosphere, oceanography, seismology.
Australia assumed responsibility for Wilkes station on 2 February 1959. Among the 1959 party are three Americans, a biologist and two meteorologists.

Lewis Islet
Location: lat. 66° 06′ S., long. 134° 22′ E., 27·5 m. above sea level.
Site: on rock. Method of supply, by sea.
Facilities available: 1 building, no accommodation.
Scientific programme: Meteorology—surface and upper atmosphere.

Belgium

Roi Baudouin
Location: lat. 70° 26′ S., long. 23° 19′ E., 50 m. above sea level.
Site: on ice shelf. Method of supply, by sea.
Facilities available: 3 large, several small huts, accommodating 22.
Electrical power: 30 kW.
Tractors, etc.: 3 Sno-cats, 1 Muskeg.
Personnel: Leader, F. Bastin.
Scientists in charge of disciplines: G. Verfaillie (chief) physicist; F. Bastin, meteorology; K. V. Blaiklock, topography; G. Dieterle, seismology; R. Ketelers, nuclear radiation; A. Kelecom, ionosphere; J. Maquet, topography; P. Sultens, nuclear radiation; T. Van Autenboer, geology; Van Decan, glaciology; A. Van der Schuren, atmospheric electricity.
Total: 10 scientists, 10 technicians, 2 others.
Scientific programme: Auroral physics, biology, cartography, cosmic rays, geology, geomagnetism, glaciology, gravity, ionosphere, meteorology—surface and upper atmosphere, seismic shooting traverses, seismology.

France

Dumont d'Urville
Location: lat. 66° 40′ S., long. 140° 01′ E., 40 m. above sea level.
Site: on rock. Method of supply, by sea.
Climate: Temperature, mean annual −10·9 °C., max. 6·1° C., min. −29·5° C.
Wind, mean annual, 11·6 m./s., extreme 70 m./s.
Cloudiness, mean annual 4·66 oktas.
Facilities available: 14 buildings, accommodating 12.
Electrical power: 60 kW.
Aircraft: 2 helicopters during summer only.
Tractors, etc.: 2 Weasels.
Personnel: Leader, R. Merle.
Scientists: F. Lazarus (chief), R. Germain, B. Groznykh, G. Guir, Dr Digeon, J. M. Noel.
Total: 7 scientists, 5 technicians.
Scientific programme: Auroral physics, biology, geomagnetism, ionosphere, meteorology—surface and upper atmosphere, oceanography, seismology.

Japan

Syowa
Location: lat. 69° S., long. 39° 35′ E., 14·5 m. above sea level.
Site: on rock. Method of supply, by sea.
Climate: Temperature, mean average −10·1° C., max. 7·4° C., min. −36° C.
Wind, mean annual 7·1 m./s., extreme 32·9 m./s.
Cloudiness, mean annual 6·6.
Facilities available: 5 buildings, accommodating 15.
Electrical power: 25 kW.
Tractors, etc.: 6 Sno-cats, 1 tractor.
Personnel: Leader, M. Murayama.
Scientists in charge of disciplines: M. Murauchi (leader), geophysics; J. Nakamura, aeronomy; M. Ose, ionosphere; Z. Seino, meteorology.
Total: 5 scientists, 4 technicians, 2 others.
Scientific programme: Auroral physics, cosmic rays, geomagnetism, glaciology, ionosphere, meteorology—surface and upper air, physiology, seismic shooting traverse, seismology.

New Zealand/U.S.A.

Hallett
Location: lat, 72° 18′ S., long. 170° 18′ E., 5 m. above sea level.
Site: on gravel spit. Method of supply, by sea.
Climate: Temperature, mean annual −15·1° C., max. 5·7° C., min. −42·2° C.
Wind, mean annual 4·3 m./s., extreme 52 m./s.
Cloudiness, mean annual 6·1.
Facilities available: 12 buildings accommodating 16.
Personnel: Chief scientist, C. L. Roberts, Jr., meteorology.
Total: 5 scientists, 3 technicians, 7 others.
Scientific programme: Auroral physics, biology, geomagnetism, ionosphere, meteorology—surface and upper atmosphere, seismology.

Norway

Norway Station
Location: lat. 70° 30′ S., long. 2° 52′ W., 557 m. above sea level.
Site: Ice shelf. Method of supply, by sea and sledge (37 km. from sea).
Climate: Temperature, mean annual −16·4° C., max. 2·3° C., min. −44·6° C.
Wind, mean annual 7·4 m./s., extreme 42 m./s.
Facilities available: 2 large, several small huts, accommodating 9.
Electrical power: two 14 kW. dynamoes.
Tractors, etc.: 1 Muskeg, 2 "Oliver" tractors.
Personnel: Scientists in charge of various disciplines: S. Helle (leader), geodesy, geomagnetism; T. Vinje, meteorology.
Total: 9 scientists, 5 technicians.
Scientific programme: Auroral physics, cartography, cosmic rays, geology, geomagnetism, glaciology, meteorology—surface and upper air, ozone measurements.

South Africa

Gough Island
Location: lat. 40° 19′ S., long. 9° 51′ W., height above sea level 7 m.
Site: on rock. Method of supply, by sea.
Climate: Temperature, mean annual 11·8° C., max. 13·9° C., min. 9·6° C.
Cloudiness, mean annual 6·6 oktas.
Precipitation, estimated annual water equivalent, 3225 mm.
Facilities available: 4 buildings, accommodating 9.
Electrical power, 2 kW.
Personnel: Leader J. Bonnema.
Total: 4 technicians, 5 others.
Scientific programme: Meteorology—surface and upper atmosphere, aurora (visual observations only).

Marion Island
Location: lat. 46° 53′ S., long. 37° 52′ E., height above sea level 26 m.
Site: on rock. Method of supply, by sea.
Climate: Temperature, mean annual 5·4° C., max. 6·3° C., min. 4·7° C.
Wind, mean annual 6·3 m./s., extreme 53·5 m./s.
Cloudiness, mean annual 6 oktas.
Precipitation, estimated annual water equivalent 2215 mm.
Facilities available: 12 buildings accommodating 11.
Electrical power: 27 kW.
Personnel: Scientist-in-charge, J. Myburgh (meteorology).
Total: 1 scientist, 5 technicians, 5 others.
Scientific programme: Aurora (visual observations only), meteorology—surface and upper atmosphere.

Tristan da Cunha
Location: lat. 37° 03′ S., long. 12° 19′ W., height above sea level 23 m.
Site: on rock. Method of supply, by sea.
Climate: Temperature, mean annual 14·5° C., max. 16·8° C., min. 12·3° C.
Wind, mean annual 61·2 m./s.
Cloudiness, mean annual 6 oktas.
Precipitation, estimated annual water equivalent, 1673 mm.
Facilities available: 4 buildings accommodating 2 families.
Electrical power available 5 kW.

Personnel: Leader N. Scheer.
Total: 2 technicians.
Scientific programme: Meteorology—surface and upper atmosphere (pilot balloons only).

United Kingdom

Port Lockroy (Base A)
Location: lat. 64° 5′ S., long. 63° 31′ W., 3 m. above sea level.
Site: on rock. Method of supply, by sea.
Climate: Temperature, mean annual −3° C., max. 8° C., min. −25° C.
Wind, mean annual 5 m./s.
Cloudiness, 6·5 oktas.
Precipitation, estimated annual water equivalent, 393 mm.
Facilities available: 5 buildings, accommodating 5.
Electrical power: 7·5 kW., 2 units.
Personnel: Leader, H. A. D. Cameron.
Total: 2 scientists, 1 technician,
Scientific programme: Auroral physics, ionosphere, absorption and whistlers studies, glaciology, ornithology.

Deception Island (Base B)
Location: lat. 62° 59′ S., long. 60° 34′ W., 8 m. above sea level.
Site: on rock. Method of supply, by sea.
Climate: Temperature, mean annual −3·5° C., max. 9′ C., min. −5·5° C.
Wind, mean annual, 6·7 m./s.
Precipitation, estimated annual water equivalent, 433 mm.
Facilities available: 3 buildings, accommodating 6.
Electrical power, 6·5 kW., 2 units.
Personnel: Chief scientist, I. Jackson.
Total: 3 scientists.
Scientific programme: Auroral physics, meteorology—surface, glaciology, ornithology, micro-meteorology.

Hope Bay (Base D)
Location: lat. 63° 24′ S., long. 56° 39′ W., 82 m. above sea level.
Site: on rock. Method of supply, by sea.
Climate: Temperature, mean annual −6·5° C., max. 11·5° C., min. −30·5° C.
Wind, mean annual 6 m./s.
Cloudiness, mean annual 5·7 oktas.
Facilities available: 1 building, accommodating 14.
Electrical power, 6·25 kW., 2 units.
Tractors, etc.: 1 Ransome M.G. 6.
Personnel: Leader, D. Mc. Calman.
Scientists in charge of disciplines: J. Ashley (chief), geophysics; J. C. Bibby geology; J. Hampton, physiology; R. M. Koerner, meteorology; D. Mc. Calman, survey.
Total: 12 scientists, 2 technicians.
Scientific programme: Auroral physics, biology, cartography, geology, geomagnetism, meteorology—surface, physiology, glaciology, ornithology.

Argentine Islands (Base F)
Location: lat. 65° 15′ S., long. 64° 16′ W., 11 m. above sea level.
Site: on rock. Method of supply, by sea.
Climate: Temperature, mean average −5° C., max. 8° C., min. −39° C.
Wind, mean annual 7 m./s.
Cloudiness, 6·7 oktas.

Precipitation, estimated annual water equivalent, 433 mm.
Facilities available: 3 buildings, accommodating 6.
Electrical power: 6·5 kW., 2 units.
Personnel: Scientists in charge of disciplines: C. R. Horton (chief), geophysics; B. D. Giles, meteorology.
Total: 7 scientists, 2 technicians, 1 other.
Scientific programme: Auroral physics, geology, geomagnetism, meteorology—surface and upper atmosphere, oceanography, seismology, ozone measurement, radiation, glaciology, ornithology.

Admiralty Bay (Base G)
Location: lat. 62° 03′ S., long. 58° 24′ W., 88 m. above sea level.
Site: on rock. Method of supply, by sea.
Climate: Temperature, mean average −4° C., max. 8° C., min. −27° C.
Wind, mean annual, 5·3 m./s.
Cloudiness, mean annual 6·4 oktas.
Precipitation, estimated annual water equivalent, 396 mm.
Facilities available: 2 buildings, accommodating 6.
Electrical power: 6·5 kW., 2 units.
Personnel: Scientists in charge of disciplines: J. Stansbury (chief), glaciology; R. Thompson, meteorology.
Total: 4 scientists, 2 technicians.
Scientific programme: Auroral physics, glaciology, meteorology—surface, ornithology.

Signy Island (Base H)
Location: lat. 60° 43′ S., long. 45° 36′ N., 7 m. above sea level.
Site: on rock. Method of supply, by sea.
Climate: Temperature, mean annual −4° C., max. 10·5° C., min. −34° C.
Wind, mean annual 7 m./s.
Cloudiness, mean annual 6·5 oktas.
Precipitation, estimated annual water equivalent 331 mm.
Facilities available: 2 buildings, accommodating 6.
Electrical power: 6·25 kW., 2 units.
Personnel: Scientists in charge of disciplines: P. Richards (chief), meteorology; O. Gorman, biology.
Total: 4 scientists, 2 technicians.
Scientific programme: Auroral physics, biology, meteorology—surface, glaciology, ornithology.

Detaille Island (Base W)
Location: lat. 66° 52′ S., long. 66° 48′ W., 7 m. above sea level.
Site: on rock. Method of supply, by sea.
Climate: Temperature, mean annual −5° C., max. 4° C., min. −25° C.
Wind, mean annual 7·7 m./s.
Cloudiness, mean annual 6·5 oktas.
Facilities available: 4 buildings, accommodating 9.
Electrical power: 6·25 kW., 2 units.
Personnel: Scientists in charge of disciplines: C. A. Murray (chief), survey; Barton, geology; Sunningham, physiology.
Total: 5 scientists, 3 technicians.
Scientific programme: Auroral physics, biology, cartography, geology, glaciology, physiology, ornithology.

Horseshoe Island (Base Y)
Location: lat. 67° 49′ S., long. 67° 17′ W., 9 m. above sea level.

Site: on rock. Method of supply, by sea.
Climate: Temperature, mean annual −3° C., max. 7° C., min. −29° C.
Cloudiness, mean annual 6·3 oktas.
Facilities available: 1 building, accommodating 5.
Electrical power: 6·25 kW., 2 units.
Personnel: Chief scientist: R. Perry, meteorology.
Total: 3 scientists, 2 technicians.
Scientific programme: Auroral physics, meteorology—surface, glaciology, ornithology.

Halley Bay (Base Z)
Location: lat. 75° 31′ S., long. 26° 36′ W., 35 m. above sea level.
Site: on ice shelf. Method of supply, by sea.
Climate: Temperature, mean annual −18° C., max. 2° C., min. −51° C.
Wind, mean annual 6·6 m./s., extreme 39 m./s.
Facilities available: 5 buildings, accommodating 20.
Electrical power: 27·5 kW., 2 units.
Tractors, etc.: 3 Ferguson diesel.
Personnel: Leader, G. R. Lush.
Scientists in charge of disciplines: M. J. Blackwell (chief), meteorology, geomagnetism, seismology, glaciology; M. A. Sheret, auroral physics.
Total: 8 scientists, 3 technicians, 1 other.
Scientific programme: Auroral physics, biology, geomagnetism, glaciology, meteorology—surface and upper atmosphere, physiology, seismology.

United States

Amundsen-Scott, South Pole
Location: lat. 90° S., 2000 m. above sea level.
Site: on inland ice. Method of supply, by air.
Climate: Temperature, mean annual −50·3° C., max. −14·7° C., min. −74·5° C.
Wind mean annual 6·5 m./s., extreme 24 m./s.
Cloudiness, mean annual 4 oktas.
Facilities available: 12 buildings accommodating 18.
Electrical power: 90 kW.
Tractors, etc.: 2 Caterpillar D2, 2 Weasels.
Personnel: Scientists in charge of disciplines: J. W. Posey (leader) meteorology; L. R. Bauhs, ionosphere and whistlers; E. J. Fremouw, aurora; N. S. Jacobs, seismology and geomagnetism.
Total: 8 scientists, 1 technician, 6 others.
Scientific programme: Auroral physics, geomagnetism, glaciology, ionosphere, meteorology—surface and upper air, seismology, whistlers.

Byrd
Location: lat. 79° 59′ S., long. 120° 01′ W., 1515 m. above sea level.
Site: on inland ice. Method of supply, by air.
Climate: Temperature, mean annual −28·5° C., max. −4·4° C., min. −63·2° C.
Wind, mean annual 8·5 m./s. extreme 42·3 m./s.
Cloudiness, mean annual 6 oktas.
Precipitation, estimated annual water equivalent, 14·1 mm.
Facilities available: 12 buildings accommodating 24.
Electrical power: 90 kW.
Tractors, etc.: 2 Caterpillar D-8, 1 Caterpillar D-4, 2 Weasels, 9 Sno-cats.
Personnel: Scientists in charge of disciplines: J. Perrit (chief), geology and glaciology; F. K. Chang, gravity and seismic shooting traverse; W. H. Chapman,

cartography; L. E. Davis, geomagnetism and seismology; H. A. Le Vaux, aurora; K. E. Marks, radio noise and whistlers; B. D. Weiss, meteorology; A. E. Woolam, ionosphere.

Total: 12 scientists, 3 technicians, 8 others.

Scientific programme: Auroral physics, cartography, geology, geomagnetism, glaciology, gravity, ionosphere, meteorology—surface and upper atmosphere, seismic shooting traverses, seismology, radio noise and whistlers.

McMurdo Sound, U.S. Naval Air Facility

Location: lat. 77° 51′ S., long. 166° 37′ E., 24 m. above sea level.

Site: volcanic ash. Method of supply, by sea, air and land.

Climate: Temperature, mean annual −17° C., max. 4·4 °C., min. −49·4° C.
Wind, mean annual 6 m./s., extreme 43 m./s.
Cloudiness, mean annual 6·2 oktas.

Facilities available: 48 buildings accommodating 112.
Electrical power: 400 kW.
Aircraft, 1 DC-3, 1 Otter, 1 helicopter.
Tractors, etc.: Caterpillar, Weasel, Sno-cat, Pole-cat.

Personnel: Scientists in charge of disciplines: M. E. Pryor (chief), biology; J. H. Dearborn, oceanography (summer only); C. Frankenfield, meteorology; W. B. Hamilton, geology (summer only).
Total: 3 scientists.

Scientific programme: Biology, geology, meteorology—surface and upper atmosphere, oceanography.

Rockford

Location: lat. 79° 35′ S., long. 152° 56′ W.

Site: on ice shelf. Method of supply, by air and tractor train.

Scientific programme: Meteorology—surface and upper atmosphere.

Opened in January for summer operations only in support of air operations.

Beardmore

Location: lat. 83° 17′ S., long. 175° 45′ E.

Site: on ice shelf. Method of supply, by air.

Scientific programme: Meteorology—surface and upper atmosphere (summer only).

U.S.S.R.

Mirnyy

Location: lat. 66° 33′ S., long. 93° E., 30 m. above sea level.

Site: on rock and ice. Method of supply, by sea.

Climate: Temperature, mean annual −10·2° C., max. 5° C., min. −40·3° C.
Wind, mean annual 11·9 m./s., extreme 46 m./s.
Cloudiness, mean annual 6·3 oktas.
Precipitation, estimated annual water equivalent, 250–300 mm.

Facilities available: 43 buildings, accommodating 14.
Electrical power: 600 kW.
Aircraft: 3 IL-12: 1 AN-2; 6 LI-2.
Tractors, etc.: 2 Weasel-type, 10 heavy Caterpillars, 10 S-80 and 10 S-100 tractors.

Personnel: Leader A. G. Dralkin.
Scientists in charge of disciplines: B. E. Brunelli, geophysics; B. A. Savel'yev, glaciology; V. I. Shlyakhov, aero-meteorology.
Total: 32 scientists, 10 technicians, 5 pilots, 48 others.

Scientific programme: Auroral physics, cosmic rays, geomagnetism, glaciology, gravity, ionosphere, meteorology—surface and upper atmosphere, seismic shooting traverses, seismology.

Vostok

Location: lat. 78° 27′ S., long. 106° 52′ E., 3420 m. above sea level.
Site: on inland ice. Method of supply, by land and air.
Climate: Temperature, mean annual −55° C., max. −22·7° C., min. −87·4° C.
Wind, mean annual, 4·6 m./s.
Precipitation, estimated annual water equivalent, 100 mm.
Facilities available: 7 buildings, accommodating 5.
Electrical power: 24 kW.
Tractors etc.: 2 heavy Caterpillars.
Personnel: Chief scientist, V. Ignatov.
Total: 3 scientists, 3 technicians, 4 others.
Scientific programme: Auroral physics, geomagnetism, glaciology, ionosphere, meteorology—surface and upper atmosphere, seismology, geography.

Lazarev

It is proposed to establish this station on the coast of Dronning Maud Land, between the Belgian and the Norwegian stations. Yu A. Kruchinin is to be in charge and the scientific programme is to comprise glaciology and meteorology—surface and upper atmosphere.

OBITUARY

Helge Götrik Backlund, the Swedish geologist, who died on 29 January 1958, was born in Dorpat on 3 September 1878. He took part in Golitsyn's expedition to Novaya Zemlya in 1897 and joined St Petersburg university the following year. He was a member of the Russo–Swedish arc of meridian expedition to Spitsbergen in 1899–1901, and in 1905 took part in Tolmachev's Khatanga expedition, working between the Yenisey and the Anabar. In 1909 Backlund started regional studies of the northernmost parts of the Ural and of the territory to the east, particularly Poluostrov Taymyr, as leader of the "Kuznetsov expedition". In 1912 he became curator of the geological museum of the Imperial Academy of Sciences in St Petersburg, but had to flee from Russia after the revolution. In 1918 he joined the staff of Åbo Akademi, engaged in geological survey in Swedish Lapland for some years, and in 1924 became professor of geology and mineralogy at Uppsala. He accompanied Lauge Koch to east Greenland in 1929, 1930 and, as chief geologist, in 1932–34. Backlund retired in 1943. One of his more important works on northern Russia is "On the eastern part of the arctic basalt plateau", *Acta Academiae Åboensis. Matematica et Physica*, 1921, Vol. 1, Nr. 2.

John R. Cruttenden was born at Quincy, Illinois, on 22 November 1915, and died there on 7 September 1956. He was one of the leading oologists of the United States. In recent years he made numerous collecting trips to Alaska and the Canadian Arctic, including five visits to Churchill, Manitoba. His vast egg collection, including many rare Arctic items such as Ross's Gull, Whooping Crane and Eskimo Curlew, is to be preserved intact in the private museum which he built for this purpose at Quincy.

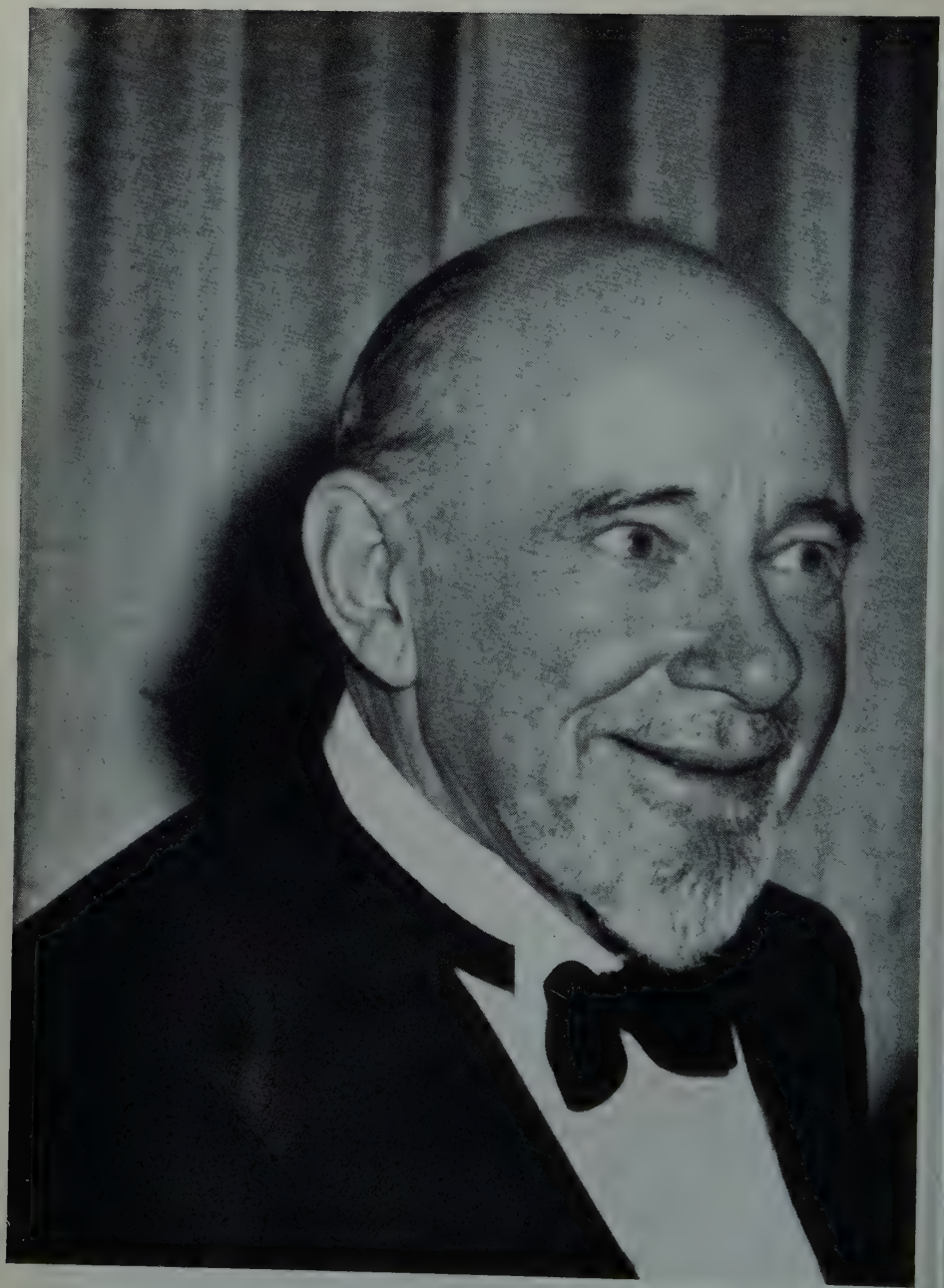
George Vibert Douglas was born in Montreal on 2 July 1892 and died in Toronto in October 1958 at the age of sixty-six.

After serving in the First World War and qualifying at Gill University he accompanied the Shackleton–Rowett Antarctic Expedition in the *Quest*, 1920–21, as geologist. On his return, the Scott Polar Research Institute provided funds and accommodation for five months while he prepard his report on the geology of South Georgia and other areas. He was the first research student to work in the Institute. He subsequently lectured in geology at Harvard University until 1926 when he became associated with mining interests. In 1932 he was appointed to the Chair of Geology at Dalhousie University.

Clifford Hamilton Easton died on 20 August 1958 at the age of seventy-five. In 1905 he accompanied Dillon Wallace on a journey by canoe and dog sledge into the then unknown interior of Labrador. The party travelled for about 3000 miles, reaching Lake Michikamu and journeying down the George River to Ungava Bay.

Michael Frank William Holland and a Danish companion, Garsten Velsboe, died in a blizzard on the ice cap above Inglefield Bredning, west Greenland, in July 1957. They were members of a Danish International Geophysical Year glaciological expedition working on the Hurlbut Gletscher.

Holland, who was twenty-nine when he died, studied at Oxford University from 1951 to 1953. He then did two years' research there on geological and physiographical material collected in Spitsbergen, for which he was awarded his B.Sc., before becoming a Tutorial Fellow at Bedford College, London. He accompanied four geological and glaciological expeditions to the Arctic before the final one on which he lost his life. In 1948 he led a party from Birmingham University to the area around Trygghamna



SIR HUBERT WILKINS

(*Facing p.* 489)

in Vest Spitsbergen. In 1951 he was a member of the Oxford and Cambridge Spitsbergen Expedition to Nordaustlandet, and two years later returned with the Oxford University expedition to the area around Von Postbreen, Vest Spitsbergen. In 1956 he led the Oxford University Expedition to west Greenland, which worked on the Sukkertoppen ice cap and made the first ascent of Mount Atter. He joined the Danish expedition, under the leadership of Børge Fristrup, in the summer of 1957.

Christopher John Blissett Kirton died as the result of an accident near the head of Billefjorden, Vest Spitsbergen, on 26 July 1958. He was a member of the Cambridge Spitsbergen Expedition, 1958, and was collecting fossils on a mountainside when he was fatally injured in a fall of scree. Kirton was a first-year undergraduate of Queens' College, Cambridge.

Thomas Hans Orde-Lees was born in Germany and died in Wellington on 2 December 1958 at the age of seventy-nine. Educated at Marlborough College, the Royal Naval School, Gosport, and Sandhurst, he was commissioned in the Royal Marines, and rose to the rank of Lieut. Colonel, R.M. He was a member of Shackleton's *Endurance* expedition, 1914–16, with the official position of "motor-expert". On his return to duty he became interested in aviation and entered the balloon service, also playing a part in the development of parachutes during the First World War. In later years he was a lecturer at Kobe University and *Times* correspondent in Japan.

André Prudhomme was born in Paris on 20 February 1920 and died on 7 January 1959 in Terre Adélie, Antarctica. He served as meteorologist on the French Antarctic Expedition, 1950–51, spending the winter of 1951 at Port Martin. He returned to Antarctica in 1958 as meteorologist to the third French I.G.Y. Antarctic expedition and was making meteorological observations at Station "Dumont d'Urville" during a blizzard when he disappeared and presumably was drowned.

Sir George Hubert Wilkins was born in Mount Brian East, Australia, on 31 October 1888 and died at Framlingham, Massachusetts, on 2 December 1958. These dates give little indication of the astonishing amount of adventure and experience which he packed into seventy years. After training at the State School and School of Mines in Adelaide, he reached Europe as a stowaway and spent four years wandering in Europe and America, eventually serving as an official photographer to the Turkish army during the Balkan war of 1912. A year later he joined Vilhjalmur Stefansson's Canadian Arctic Expedition, 1913–18, as photographer, and was one of the party which became separated from the *Karluk* when she was beset off Point Barrow and drifted westwards to her doom in the Chukchi Sea. The party had to "live off the land" while travelling some 5000 miles on foot. Wilkins became second-in-command, and during the three years he was with this expedition absorbed much invaluable experience in polar techniques. He had learned to fly in 1910–12, and now formed the idea of flying over the Arctic Ocean. However, his proposal to Stefansson that they should go south and get aeroplanes did not find favour. He left the expedition in 1917 to enlist with the Australian Flying Corps, was promoted to captain and was awarded the Military Cross with bar. At the end of 1917 he was seconded to the Military History Department and commanded the photographic section of the Australian forces in France.

At the end of the war, Wilkins immediately turned again to thoughts of the Arctic. In 1919 he planned a flight from Spitsbergen to Alaska, but failed to secure a suitable aeroplane; his ideas were regarded as fantastic. The same year he was navigator for one of the pioneer flights from England to Australia.

In 1920 an ambitious British Antarctic expedition was planned by J. L. Cope—with Wilkins as second-in-command—to survey the east side of the Ross Sea and

to reach the South Pole by air. Twelve surplus aircraft were acquired by gift from the Royal Air Force Disposal Board; they were to be used in relays and abandoned in succession along the route. These plans had to be abandoned owing to lack of support, and the aircraft were returned to the R.A.F. Instead, Cope and Wilkins, with T. W. Bagshawe and M. C. Lester, went to Graham Land in whaling vessels in 1920, intending to sledge southwards from Hope Bay and explore the west and south coasts of the Weddell Sea. The ice prevented access to Hope Bay, and Cope and Wilkins returned to England, leaving the other two members of the party to winter on the west coast. Wilkins then joined the Shackleton–Rowett Antarctic Expedition in the *Quest*, 1921–22, during which he devoted his attention to ornithological observations.

While he was working in the British Museum (Natural History) on the specimens brought back by the *Quest*, Wilkins was selected by the Trustees to lead a collecting expedition to tropical Australia, a task which he successfully performed between 1923 and 1925.

Returning to the Arctic, Wilkins spent the next three years making pioneer exploratory flights with Carl Ben Eielson as pilot. He has described these years as: "We begged for money, bought machines, flew them and smashed them, rebuilt them and smashed ourselves".

In 1926 and 1927 his object was to explore the unknown area immediately to the north of Alaska. The logical base was Point Barrow, but supplies had first to be collected there. Most of the 1926 season was devoted to flying stores from Fairbanks to Point Barrow, and longer flights could not be made, but the route lay across an interesting and then unknown section of the Brooks Range. In 1927 Wilkins decided to penetrate the unexplored region of the Arctic Ocean between the tracks of the *Norge* and the *Jeannette*. On 29 March 1927 Wilkins and Eielson flew north-west from Point Barrow for some 500 miles and landed on the pack ice in about lat. 77° 45′ N., long. 175° W. With an echo sounder he determined the depth as 5440 m., a measurement which later investigators considerably reduced. During the return flight, headwinds forced them to land on the pack ice about 100 miles from Point Barrow. From here the current drifted them 200 miles in six days; they abandoned the aircraft and walked 80 miles to the Alaska coast at Beechey Point, building snow houses for shelter on the way. Another flight, north-eastwards from Point Barrow in May 1927, to beyond 74° N., disclosed nothing but pack ice.

In 1928 Wilkins proposed to continue his examination of the area north-east of Point Barrow by flying 2100 miles across the Arctic Ocean to Spitsbergen via northern Ellesmere Island. In a 20-hour flight on 15–16 April he and Eielson brilliantly completed this project, greatly reducing the unknown area. It was a remarkable achievement in air navigation for which he was knighted by King George V and received the Patron's Medal of the Royal Geographical Society.

Next, he turned south again as leader of the Wilkins–Hearst Antarctic Expedition, 1928–29. After several preliminary flights from Deception Island (that on 16 November 1928 being the first ever made in the Antarctic), Sir Hubert took off for his main exploratory flight on 20 December with C. B. Eielson as pilot. They flew down the east coast of Graham Land for 600 miles to about lat. 71° 20′ S., and returned by practically the same route. A second flight, on 10 January 1929, 250 miles out in the same direction, appeared to confirm the observations of the previous flight. Although the original intention to fly across the continent to the Ross Sea was frustrated by bad weather, and the discoveries reported have since nearly all been shown to be erroneous, this was a major achievement in aviation which demonstrated both the possibilities and the limitations of aerial exploration in the Antarctic. The furthest south point sighted was named "Hearst Land" (now identified as Hearst Island). The results suggested that Graham Land was an archipelago separated from

the mainland by "Crane Channel", "Casey Channel" and "Lurabee Channel" (now Crane, Casey and Lurabee Glaciers) and "Stefansson Strait" (now Stefansson Sound). The existence of these east-west channels has since been disproved, but the lessons learnt by this pioneer reconnaissance greatly influenced the course of all subsequent exploration in the area.

The following season, 1929–30, Sir Hubert returned to the Antarctic, this time with the "Discovery" Committee's *William Scoresby* as tender, in the hope of flying westwards along the mainland coast from Graham Land to the Ross Sea. Further flights in northern Graham Land as far south as Leroux Bay and eastwards to Richthofen Pass appeared to confirm and extend the erroneous discoveries of 1928. Charcot Land was shown to be an island, and an important reconnaissance flight southwards to about lat. 73° S., in long. 101° W., revealed nothing but pack ice. No suitable site could be found for a starting point of the proposed trans-continental flight, which accordingly had to be postponed once more.

Sir Hubert's failure to penetrate the belt of pack ice off the coast of the Pacific sector of Antarctica with the *William Scoresby* in 1929 caused him to seek alternative methods. His mind turned to submarines, which he thought might pass under the ice. He was obsessed with the idea that future polar air routes and long-range weather forecasting would require meteorological stations in many inaccessible places, and that means must be found to reach and maintain these stations. By 1931 his ideas had advanced sufficiently for practical trial, and he launched his project to reach the North Pole by diving under the pack ice of the Arctic Ocean. He obtained the loan of the submarine O 12 from the United States Navy, renamed her *Nautilus* after Jules Verne's visionary tale, and left Longyearbyen, in Vest Spitsbergen, on 18 August 1931. H. U. Sverdrup accompanied the venture as chief scientist. Unfavourable weather and damage to the vessel's diving gear forced him to turn back at lat. 82° 15′ N., but a rich harvest of scientific results and practical experience was obtained, and Sir Hubert became convinced of the practicability of under-ice travel. Although he was again ridiculed for his ideas, and was not successful in obtaining support for building a new submarine specially for polar work, he lived to see full vindication with the trans-Arctic under-ice voyages of the U.S.S. *Nautilus* and U.S.S. *Skate* in 1958.

Lincoln Ellsworth had been joint leader of the earlier *Nautilus* expedition in 1931 and he, too, became fired with Sir Hubert Wilkins' enthusiasm for a trans-Antarctic flight. The two men worked in close co-operation, and during Ellsworth's expeditions of 1933–34, 1934–35, 1935–36 (when the first trans-Antarctic flight was successfully accomplished) and 1938–39, Sir Hubert was responsible for the administrative details at the bases and on board the *Wyatt Earp*. In 1937 and 1938 he also made a number of flights over the Beaufort Sea and northern Alaska to search for the Russian aviator Levanevskiy and his five companions, who had been lost during a flight from Moscow to Fairbanks in August 1937.

During the Second World War Sir Hubert Wilkins was based in Washington, where his advice was constantly sought in connexion with Arctic problems. From 1942 to 1952 he served as consultant to the United States Military Planning Division, working mainly in the Office of the Quartermaster General, designing and testing cold climate equipment and conducting field trials in Alaska. Since 1953, he continued this work as geographer in the Research and Development Command, United States Department of Defence.

Among many publications, he wrote *Undiscovered Australia* (London, 1928), *Flying the Arctic* (New York and London, 1928), *Under the North Pole: the Wilkins–Ellsworth submarine expedition* (New York, 1931), *Thoughts through space: a remarkable adventure in the realm of the mind* (New York, 1942), and numerous contributions to periodicals.

B.B.R.

RECENT POLAR LITERATURE

This selected bibliography has been prepared by R. J. Adie, Terence Armstrong, T. H. Ellison, Amorey Gethin, J. W. Glen, W. B. Harland, H. G. R. King, Brian Roberts and Ann Savours. Its main field is the polar regions, but it also includes other related subjects such as "applied" glaciology (e.g. snow ploughs and ice engineering). For the literature on the scientific study of snow and ice and of their effects on the earth, readers should consult the bibliographies in each issue of the *Journal of Glaciology*. For Russian material, the system of transliteration used is that agreed by the U.S. Board on Geographic Names and the Permanent Committee on Geographical Names for British Official Use in 1947 (see *Polar Record*, Vol. 6, No. 44, 1952, p. 546).

Reprints of "Recent Polar Literature", from Nos. 37/38 onwards, can be obtained separately (to allow references to be cut out for pasting on index cards) from the Institute, price 2*s*. 6*d*. for two reprints. Copies will be sent without charge to organizations with which the Institute maintains exchange arrangements and which notify their wish to receive them. Readers can greatly assist by sending copies of their publications to the library of the Institute.

To increase the usefulness of the bibliography entries have been arranged provisionally under subject headings in classified order according to the Universal Decimal Classification. When circumstances permit the decimal notation will be included, together with a key.

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[TERRES AUSTRALES ET ANTARCTIQUES FRANÇAISES : LAWS] Extrait du "Journal Officiel" de la République française du 9 août 1955, page 7979 . . . *Terres Australes et Antarctiques Françaises* (Paris), No. 1, 1957, p. 24–25. [Extract from law No. 55–1052, 6 August 1955, making Terres Australes et Antarctiques Françaises administratively and financially autonomous.]

[TERRES AUSTRALES ET ANTARCTIQUES FRANÇAISES : LAWS] Textes officiels. Arrêté No. 10 l'administrateur supérieur des Terres Australes et Antarctiques Françaises. *Terres Australes et Antarctiques Françaises* (Paris), No. 3, 1958, p. 28. [Decree establishing administrative authority in Terres Australes et Antarctiques Françaises. (B.O. no. 175, 2. 11. 561).]

ERRATA

The *Polar Record*, No. 58, January 1958

Page 31, title of photograph opposite. *For* Cape Anna *read* Spigot Peak. On the left of the photograph is the southern part of Orme Harbour, Cape Anna forms its northern entrance and off the picture to the left.

The *Polar Record*, No. 59, May 1958

Page 141, lines 41 and 44. *For* West Greenland *read* Vestspitsbergen.

The *Polar Record*, No. 60 September, 1958

Page 248, line 10. *For* Forster *read* Foster.

Page 257, line 12. *Omit* P. C. Delrymple, glaciologist; line 26–30. *Transfer* A site... Liv Glacier *to* page 260, under *Naval Air Facility, McMurdo Sound.*

Page 258, line 17. *After* glaciologist; *insert* P. C. Dalrymple, glaciologist;.

Page 259, line 7. *For* Morgensen *read* Mogensen.

Page 260, line 16. *For* Commander W. F. Flynn *read* Lt. Commander S. W. Marshall.

The *Polar Record*, No. 61, January 1959

Page 358, line 22. *For* "Melchoir" *read* "Melchior"

Index to Vol. 8, *Polar Record*

Page 24, line 37. *For* Swithinbank, C. H. W. *read* Swithinbank, C. W. M.

THIRTY-SECOND ANNUAL REPORT ON THE WORK OF THE SCOTT POLAR RESEARCH INSTITUTE

The General Board beg leave to publish the following Report which they have received from the Director of the Scott Polar Research Institute on the work of the Institute for the year ending 21 July 1958.

Teaching and Research. Dr Armstrong and Dr Roberts gave a course of eight lectures on "Polar problems" in the Easter Term, 1958, to candidates for Part II of the Geographical Tripos.

Sea ice studies have continued, with Dr Armstrong in general charge. Dr Swithinbank, continuing his ice probability analysis of Canadian arctic waters undertaken for the Defence Research Board of Canada, spent part of the year in Canada and in Denmark in order to collect data. Mr J. A. Heap of the Falkland Islands Dependencies Scientific Bureau has continued his study of ice in the waters of the Dependencies.

Mr R. J. E. Brown of the National Research Council, Ottawa, spent the year at the Institute working on permafrost problems.

Mr R. Mutter began work at the Institute in July 1958 on a two-month study of "Resource Development of the Canadian Sub-Arctic".

Dr Roberts has continued work on Antarctic history and place-names.

Dr Robin and Dr Swithinbank have continued work on results of the Norwegian–British–Swedish Antarctic Expedition, 1949–52.

Information Service. Visitors using the Institute's collections for short periods included:

Professor J. L. Mohr, University of Southern California inspecting Russian marine biological reports from the Arctic Ocean.

Mr P. A. Hulton, British Museum, investigating drawings of Eskimo by John White (fl. 1585–1600).

Miss Mander-Jones, Mitchell Library, Sydney, N.S.W., searching for historical material of Australian interest.

Miss A. Parry, working on a biography of Admiral Sir William Edward Parry, 1790–1855.

Dr W. J. L. Sladen, Johns Hopkins University, working on Antarctic ornithology.

Mr Weston Blake Jr. of Ohio State University and Stockholms Högskola, who is engaged on field studies of the glaciology and glacial geology of Nordaustlandet, inspecting original records of expeditions to this area.

Professor Robert E. Johnson, University of Illinois, who is interested in historical aspects of the physiology of arctic exploration, consulting the manuscript collection.

Special Committee on Antarctic Research. Dr Robin, the U.K. delegate to the Special Committee on Antarctic Research of the International Council of Scientific Unions (S.C.A.R.), has been Acting Secretary of that Committee since April 1958. This has entailed much extra work for the office staff, but has resulted in close contact with the twelve nations now active in Antarctic research.

Visits. Dr Robin represented the U.K. at the International Geophysical Year Antarctic Symposium held in Wellington, New Zealand, from 18 to 22 February 1958.

Dr Armstrong, Dr Swithinbank, and Mr Heap took part in the Arctic Sea Ice Conference at Easton, Maryland, from 25 to 27 February 1958.

Dr Swithinbank attended the International Union of Geodesy and Geophysics meeting in Toronto, from 3 to 14 September 1957.

Staff. Dr G. de Q. Robin took up his appointment as Director on 1 April 1958.

Dr T. E. Armstrong was appointed an Assistant Director of Research (Polar esearch) from 1 October 1957.

Miss A. N. Macdonald left the Institute on 31 October 1957, and was succeeded y Mrs K. M. Hyde, as secretary to the Director, on 18 October 1957.

Miss S. E. Webb, an assistant secretary, left the Institute on 16 September 1957.

Finance. During the year the Institute received the following sums, which are ratefully acknowledged.

Ministry of Defence. The sum of £1500 was received on 6 August 1957 and £500 on 17 April 1958.

Australia. A donation of £398. 16*s.* 1*d.* (£A500) authorized by the Australian Cabinet was received on 29 May 1958.

Falkland Islands Dependencies Administration. A ninth annual subvention of £100 was made by the Governor of the Falkland Islands and was received on 14 January 1958.

South Africa. A donation of £200 sterling from the South African Government was received on 11 March 1958; and an advance donation of £300 for 1958–59 was received on 11 April 1958.

New Zealand. A grant of £100 sterling was received from the New Zealand Government on 16 October 1957.

Canada. £751, 17*s.* 8*d.* ($2000 Canadian) was received on 29 July 1957, and £361. 0*s.* 3*d.* ($1000 Canadian) on 24 February 1958 under a contractual agreement with the Defence Research Board of Canada covering the years 1955–58.

Publications. Since the last Annual Report was published, three numbers of the *Polar Record*, Nos. 57, 58, and 59, and the Index to Vol. VII have been issued.

The following publications by the staff are noted:

Illustrated ice glossary, Part 2 (*Polar Record*, 1958), T. E. Armstrong and B. B. Roberts.

Chronological list of Antarctic expeditions, Part 1, up to 1899 (*Polar Record*, 1958), B. B. Roberts.

A. The morphology of the ice shelves of western Dronning Maud Land and *B. The regime of the ice shelf at Maudheim as shown by stake measurements* (*Norwegian–British–Swedish Antarctic Expedition Scientific Results*, Vol. 3, Norsk Polarinstitutt, Oslo, 1957), C. W. M. Swithinbank.

Lectures. Lectures were given at the Institute during the Michaelmas and Lent Terms.

1957

26 October	"The future of Antarctica", by Dr G. C. L. Bertram.
9 November	"Soviet expeditions in the Arctic and Antarctic" (Documentary films).
23 November	"Antarctic air survey", by P. G. Mott.

1958

25 January	"The South Georgia Survey", by V. D. Carse.
8 February	"The new look in northern Canada" (films), by Wing Commander G. J. Bury, R.C.A.F.
1 March	"Permafrost in Canada", by R. J. E. Brown,

Friends of the Polar Institute. The membership is now 265, representing a total subscription of about £391 a year. The continued generosity and support of the Friends is greatly appreciated.

Gino Watkins Memorial Fund. Loans of equipment for use during the summer of 1958 were made this year to six expeditions.

Museum. An exhibition of photographs taken during the continental journey of the Trans-Antarctic Expedition, 1955–58, was held in the museum during the summer. Most of these photographs were lent by the Trans-Antarctic Expedition Committee.

Mr Edward Seago, who accompanied H.R.H. the Duke of Edinburgh on his world tour in 1956–57 as official artist, has presented to the Institute one of his oil-paintings of Antarctic scenes, "The first iceberg, December 26, 1956".

Library. Publications received during the year numbered 1730. Of these 552 were gifts, 261 were purchased and 917 received in exchange for the *Polar Record*. These totals include over 400 periodicals and serial publications. Maps and charts numbered 823 of which 149 were gifts, 13 purchases and 661 received in exchange. Over 3300 abstracts of periodical and other literature were compiled by the staff and outside contributors and added to the classified catalogue; 1260 selected abstracts were published in the *Polar Record.*

The manuscript collection has been greatly enriched by the gift of the papers of Admiral Sir William Edward Parry (1790–1855), who led four British naval expeditions to the Arctic between 1819 and 1827. The papers, which include 15 bound notebooks and journals and more than 1000 letters, were presented by Admiral Sir Edward Parry, K.C.B. This fine gift is very much appreciated by the Institute.

A number of microfilm copies of logs of sealers visiting the South Shetland Islands have been acquired by gift and purchase during the year. These include, the logs of the *Hersila*, 1819–20; *Hero*, 1820–33; *Huntress*, 1820; *Penguin*, 1829–31; and *Grönland*, 1873–74.

A provisional inventory of the manuscript collection has been completed by Miss Ann Savours. Additions to the Institute's manuscript collection are now listed yearly in the *Bulletin of the National Register of Archives* (London).

Once again the Institute would like to thank Miss C. K. Golding of Exeter for her voluntary indexing work.

Gifts. The Institute is most grateful for the publications sent to the Library in exchange for the *Polar Record* and regrets the impossibility of acknowledging each one individually.

We wish to thank the many people and organizations who have so kindly presented the following items:

Books and reprints

Dr O. Abs
G. N. Appell
Mrs G. N. Appell
Dr T. E. Armstrong
W. B. Bailey
F. K. Ball
Professor A. Bauer
M. B. Bayly
Dr L. O. Belopol'skiy
Dr G. C. L. Bertram
P. Biays
Captain R. B. Black, U.S.N.
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J. E. Greenwood
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R. A. Hamilton
J.-E. Hansson
Professor F. K. Hare
W. B. Harland
M. Hartley
J. B. Heaney
J. A. Heap
Profvessor H. R. Hewer
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Kaptajn E. Mikkelsen
Dr M. M. Miller
Dr E. Mohr
Professor J. L. Mohr
P. G. Mott
Professor S. W. Muller
Professor T. Nagata
Miss I. Nicholson
Dr F. Nusser
Dr J. F. Nye

Books and Reprints (cont.)

Dr E. Palosuo
Admiral Sir Edward Parry, K.C.B.
J. Paton
Dr P. Paulian
Professor Ch.-P. Péguy
R. A. J. Phillips
Sir Raymond Priestley
Dr F. Prohaska
Dr N. W. Radforth
P. A. Rainbow
Dr B. B. Roberts
Dr G. de Q. Robin
C. H. Fraser Rowell
G. W. Rowley
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Dr V. B. Scheffer
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R. Self
G. Seligman
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A. Watson
R. Webbe
H. Wexler
K. Whitham
P. J. Williams
R. B. Williams
Dr J. W. Wilson
Sir James Wordie

Admiralty. Hydrographic Department
Admiralty. Intelligence Division
Aerial Survey Review
Air Ministry. Meteorological Office
Alaska. Department of Health
Alaska. Rural Development Board
American Meteorological Society
Australia. Commonwealth Scientific and Industrial Research Organization
Australia. Department of National Development. Bureau of Mineral Resources, Geology and Geophysics
British Columbia. Department of Lands and Forests. Water Rights Branch
British Embassy Washington. Library
British Embassy Washington. Office of the Air Attaché
British Glaciological Society
British Joint Services Mission Washington. Army staff
British North Greenland Expedition, 1952–54
British Shipbuilding Research Association
Bundestorschungsanstalt für Seefischerei, Hamburg
Bureau de l'industrie et du commerce de Québec metropolitan inc.
Canada. Defence Research Board
Canada. Department of External Affairs
Canada. Department of National Health and Welfare
Canada. Ministry of Veterans Affairs
Canada. Post Office Department
Canadian Institute of International Affairs
Canadian Institute of Mining and Metallurgy
Cariboo Digest Limited, Quensel, British Columbia
Carter Observatory, Wellington
Cement and Concrete Association, London
Central Library of the Hydrometrical Service of the U.S.S.R.
Centre Nationale de la Recherche Scientifique, Paris
Decca Radar Limited, London
J. M. Dent and Sons Limited, London
Deutsches Hydrographisches Institut, Hamburg
Embassy of the Polish People's Republic, London
Expédition Antarctique Belge
Falkland Islands. Colonial Secretary's Office
Falkland Islands and Dependencies Meteorological Service
Falkland Islands Dependencies Scientific Bureau
Foreign Policy Association, New York
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Hodder and Stoughton, Limited, London
Hollis and Carter, London
Hudson Bay Route Association
Hunting Technical and Exploration Services Limited, London
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Imperial Chemical Industries Limited, London
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International Commission on Whaling, London
International Geographical Union
Iowa Engineering Experiment Station. Soil Research Laboratory
Japan. Ministry of Education
Japanese National Commission for UNESCO
McGill University. Arctic Meteorology Research Group
McGill University. Department of Geography
Ministry of Defence
Musée Océanographique de Monaco
National Academy of Sciences. National Research Council, Washington
National Aeronautical Establishment, Ottawa
National Institute of Oceanography
National Register of Archives

National Science Foundation, Washington
La Nature, Paris
New Brunswick. Department of Lands and Mines
New York. Department of Sanitation
New Zealand House, London
New Zealand Navy Office, Wellington
Norsk Folkemuseum, Oslo
Northern Canada Power Commission
Provincial Museum, British Columbia
Research Council of Alberta
Royal Committee for the International Geophysical Year
Royal Society
Royal Society of Edinburgh
Ruberoid Co., Limited, London
Skid-och Frilufts-Främjandet, Stockholm
Soviet I.G.Y. Committee
Trust Society for the Furtherance of the Gospel
U.S. Air Force. Cambridge Research Center
U.S. Army Corps of Engineers. Arctic Construction and Frost Effects Laboratory
U.S. Army Headquarters Quartermaster Research and Development Command
U.S. Army. Office of the Chief of Engineers
U.S. Department of Defense
U.S. Embassy London. Office of the Army Attaché
U.S. National Park Service
U.S. Navy. Hydrographic Office
U.S. Office of Naval Research, London
Université Laval, Institut de Géographie
University of Alaska, Geophysical Institute
University of Oxford, Department of Geology and Mineralogy
V.E.B. Geophysik der Staallichen Geologischen Kommission
War Office, London
Wärtsilä-koncernen A/B Sandvikens Skeppsdocka, Helsingfors
Wayfarers' Club
Weather Bureau, Pretoria
Whaling Museum Society, Inc., Cold Spring Harbor

Maps and charts

Dr H. P. Kosack
Dr B. B. Roberts
Dr C. W. M. Swithinbank
Admiralty. Hydrographic Department
Australia. Department of External Affairs. Antarctic Division
Directorate of Overseas Surveys, Tolworth
Embassy of Japan, London
Expéditions Polaires Françaises, Paris
New Zealand. Department of Lands and Survey
Norsk Polarinstitutt, Oslo
Province of Ontario. Department of Mines
Province of Saskatchewan. Department of Natural Resources, Surveys Office
U.S. Coast and Geodetic Survey
U.S. Army Map Service

Manuscripts, etc.

Track charts of M.V. *Kista Dan*, Australian National Antarctic Research Expedition, 1957	Antarctic Division, Department of External Affairs, Melbourne
Papers and minutes of the Antarctic Place-names Committee, 1955–57	Antarctic Place-names Committee, London
Copies of original topographical surveys of South Georgia by the South Georgia Survey, 1951–57, leader V. D. Carse	V. D. Carse
Photostat copies of papers relating to the British Relief Expeditions to McMurdo Sound, Antarctica, 1902–04, commanded by Captain William Colbeck, R.N.R.	Captain W. R. Colbeck, R.N.
Meteorological log of the British Antarctic Expedition, 1907–09, leader Sir Ernest Shackleton	Commonwealth of Australia, Bureau of Meteorology
Letter to the press dated 4 September 1914, concerning the Australian Antarctic Expedition, 1911–14, leader Sir Douglas Mawson	R. E. Cooper
Letters written by G. A. Giffard during the British Arctic Expedition, 1875–76, leader Sir George Nares	Miss E. Giffard
Route charts used during the donor's flight over the arctic air route from Rochester to New York, 1934	John Grierson
Typescript copy of original journal kept by F. A. Worsley during the British Imperial Trans-Antarctic Expedition, 1914–16, leader Sir Ernest Shackleton. Original in the possession of J. W. S. Marr	Alfred Lansing
Birdlog kept aboard the tanker *Southern Satellite*, 1956–57, in the South Atlantic and Southern Oceans	Neil MacLeod
Unpublished topographical maps of the Falkland Islands Dependencies, 1944–56	D. H. Maling

Microfilm copy of the original log book of Nantucket sealer *Huntress*, 1820–21	Marine Historical Association, Mystic, Connecticut
Letters, journals and correspondence of Admiral Sir William Edward Parry, 1799–1855	Admiral Sir Edward Parry, K.C.B.
Copies of unpublished topographical maps of the Falkland Islands Dependencies, 1950–55	Dr B. B. Roberts
Copies of unpublished track charts of U.S. ships *Glacier*, *Wyandot*, and *Staten Island*, Operation "Deep Freeze II' and 'III', 1956–58	Lieut. Cdr. G. St Aubyn, R.N.
Journals kept by J. H. Martin during the British Graham Land Expedition, 1934–37, leader J. R. Rymill, and during other arctic and antarctic voyages	Mrs C. Simpson
Engineering drawings of *Discovery*, 1900–01	Cmdr. W. F. Skelton, R.N.
Ice track charts of H.M.C.S. *Labrador* in the eastern Canadian Arctic, 1955–56	Dr C. W. M. Swithinbank
Plans of twin screw U.S. Navy small cargo ships (ice strengthened) T-AK270 class, 1955	U.S. Office of Naval Research, London

Photographs, negatives, slides, films, etc.

Captain R. B. Black, U.S.N.	V. Stefansson
Captain A. G. Bomford, R.E.	C. W. M. Swithinbank
Mr. E. J. Brown	H. Toya
Mr. N. Rudmose Brown bequest	W. H. Ward
Mr. D. Carse	Admiralty
Mr. J. Carson	Arctic Institute of North America
Mr. K. Davis	Australian National Antarctic Research Expeditions
Mr. Evans	Canada. Department of Mines and Technical Surveys
Baron G. de Gerlache de Gomery	Embassy of Polish Peoples' Republic
Miss E. Giffard	Gough Island Scientific Survey, 1955–56
Ernst Höfer	Hunting Aerosurveys Limited
Mr. A. Hulton	Japanese Ministry of Education
Mr. Imbert	H.M.C.S. *Labrador*
Mr. Lauritzen	National Institute of Oceanography
Mr. C. Lester bequest	Nippon Polar Research Institute
Mr. V. V. Lewis	Nordisk Mineselskab A/S
Professor P.-L. Mercanton	Royal Canadian Air Force
Mr. Muller	Trans-Antarctic Expedition, 1955–58
Mr. M. Pennie	United States Office of Naval Research
Lieut. Cdr. G. St Aubyn, R.N.	
Mr. C. Shelesnyak	

Museum exhibits, equipment, etc.

Ship's flag of *Terra Nova*, used during British Antarctic Expedition, 1910–13	W. C. Auld
Two watercolours of H.M.S. *Alert*, British Arctic Expedition, 1875–76. One signed "C. R. Ricketts, 1875", and one unsigned	Miss E. Giffard
Official philatelic cover of Trans-Arctic Expedition, 1955–58, posted from "Scott Base"	N. E. Odell
Union Jack which was hoisted on the sledgeboat *Endeavour* by Admiral Sir William Edward Parry in lat. 82° 45′ N.	Admiral Sir Edward Parry, K.C.B.
Barometer from ward-room of *Terra Nova*	Mrs A. S. St Clare
Oil painting "The first iceberg, December 26, 1956". By Edward Seago	Edward Seago

G. DE Q. ROBIN, *Director*

NOTICES

The *Polar Record* is published in January, May and September each year. Contributions, also books and papers for listing in the bibliography of "Recent Polar Literature", should be addressed to the Editor, Scott Polar Research Institute, Lensfield Road, Cambridge, England.

Every effort is made to enable authors of articles to receive proofs, which they are requested to return without delay. Proofs of notes are not normally submitted to authors, except when especially requested.

Twenty-five reprints of articles are supplied free to authors; additional copies, which are provided at cost price, should whenever possible be requested on submitting the contribution. Reprints of notes are not normally supplied.

Correspondence arising out of notes and articles is welcomed.

The Scott Polar Research Institute is a signatory of the Royal Society's "Declaration on fair dealing in regard to copying from scientific periodicals". Details of the Declaration may be obtained upon application from the offices of the Royal Society, Burlington House, London, W. 1.

The cover of the journal is from a photograph by Hunting Aerosurveys Ltd., taken during the Falkland Islands Dependencies Aerial Surveys Expedition, 1955–57.

PUBLICATIONS FOR SALE AT THE SCOTT POLAR RESEARCH INSTITUTE

Scientific Reports of the Terra Nova expedition, 1910–13

Reports dealing with meteorology, terrestrial magnetism, gravity determination, aurora observations, physiography and miscellaneous data are still available. For a detailed list, and prices, see the inside back cover of the *Polar Record*, No. 44.

Back issues of the Polar Record

A few sets of the *Polar Record*, Volumes 1–5 (Nos. 1–40), including indexes, are available, price £60 at the discretion of the Editorial Committee; also the following separate issues at seven shillings and sixpence each:

Nos. 1, 2, 3, 4, 17, 19, 31, 32, 39 to 57. Nos. 58 onwards are ten shillings and sixpence each.

Nos. 33/34, 35/36, and 37/38. These are double numbers and are fifteen shillings each.

Indexes for Volume 1 (Nos. 1–8), Volume 2 (Nos. 9–16) and Volume 3 (Nos. 17–24) are five shillings each, the index for Volume 4 (Nos. 25–32) is ten shillings, the index for Volume 5 (Nos. 33/34–40) is free and the indexes to Volume 6 (Nos. 41–46), Volume 7 (Nos. 47–51) and Volume 8 (Nos. 52–57) are ten shillings each.

Reprints of "Recent Polar Literature", from Nos. 37/38 onwards, are two shillings and sixpence for two reprints for each issue.

Reprints of "Illustrated Ice Glossary", by Terence Armstrong and Brian Roberts, from Volume 8, No. 52, 1956, and Volume 9, No. 59, 1958, are five shillings each.

Reprints of "Chronological list of Antarctic expeditions", by Brian Roberts, from Volume 9, Nos. 59 and 60, 1958, are seven shillings and sixpence each.

An illustrated descriptive pamphlet entitled *The Scott Polar Research Institute* is two shillings and ninepence.

Prices are subject to alteration without notice.

"FRIENDS OF THE POLAR INSTITUTE"

This association was established in March 1946 with two objects in view: first to provide a means whereby those interested in the promotion of polar exploration and research might assist the Scott Polar Research Institute, and secondly to keep members in touch both with the Institute and with present polar activities. Members receive the Annual Report of the Committee of Management, which describes the work and progress of the Institute, and the Annual Report of the "Friends of the Polar Institute".

The minimum annual subscription is one guinea. British taxpayers who are able to subscribe by covenanted agreement for a period of seven years will be giving additional assistance to the Institute. "Friends" are asked to subscribe separately to the journal of the Institute, the *Polar Record*.

The "Friends" have been the means of giving very valuable help to various sides of the Institute's work. Subscriptions are used principally for making accessions to the Museum and Library, for providing furniture and equipment, and for special needs which cannot be met from other sources.

SUBSCRIPTION TO THE *POLAR RECORD*

The *Polar Record* may be obtained direct from the Scott Polar Research Institute, Lensfield Road, Cambridge, England, or through any bookseller. The subscription is thirty-one shillings and sixpence a year, or ten shillings and sixpence a single copy, post free.

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